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TRANSACTIONS OF THE NEW YORK ACADEMY OF SCIENCES

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Executive Director: EUNICE THOMAS MINER

REPORT OF THE ANNUAL MEETING

December 5, 1957

The 140th Annual Meeting of the Academy, for the election of Fellows, the presentation of reports, and the transaction of other business, was held at the Academy Building on the evening of Thursday, December 5, 1957.

The first order of business was devoted to the reports of the Officers and Committees of the Academy.

REPORTS OF OFFICERS AND COMMITTEES

Report of the Recording Secretary

The year just passed, the 141st year of the Academy's history saw a continuation in the upward swing of its growth curve of activities with excellent results of progress and accomplishment. Except for the total number of conferences held, all other facets of the Academy's activities, covering its financial status, membership, publications, general printing by the Academy's Press, and the schedule of meetings held have set a new high in the record for achievement.

The fifteen conferences held were very carefully planned for their significant contributions to the specific fields selected. The attendance in each case was most gratifying and represented investigators from the United States and other countries especially interested in furthering the subjects under consideration. The Academy extends its deepest thanks and gratitude to the 639 scientists who developed the programs and who presented the 463 important papers and discussions that now have been included in the monographs resulting therefrom.

The list of these conferences and the names of their organizers give further evidence of the great effort made by the Academy to foster and further the continuous advancement of Science:

"Proteolytic Enzymes and Their Clinical Application," November 8 and 9, 1956; Conference Chairman, Gustav J. Martin, The National Drug Company, Philadelphia, Pa.; Organizing Committee: L. Earle Arnow, Merck Sharp & Dohme, Rahway, N. J.; J. M. Beiler, The National Drug Company, Philadelphia, Pa.; Walter C. Dietrich, The National Drug Company, Philadelphia, Pa.; Emil A. Fullgrabe, The Armour Laboratories, Kankakee, Ill.; B. L. Hutchings, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.; Gustav J. Martin, The National Drug Company, Philadelphia, Pa.; William Swain, The National Drug Company, Philadelphia, Pa.; Max Tishler, Merck Sharp & Dohme, Rahway, N. J.; and J. H. Williams, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.

"Subcellular Particles in the Neoplastic Process," November 19 and 20, 1956; Conference Co-Chairmen, C. P. Rhoads, Memorial Center for Cancer and Allied Diseases, New York, N. Y. and Hilary Koprowski, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.

"The Role of I^{131}-Labeled Proteins in Biology and Medicine," November 30, 1956; Conference Chairman, S. P. Masouredis, Central Blood Bank, University of Pittsburgh, Medical School, Pittsburgh, Pa.

"Biological Applications of Infrared Spectroscopy," December 7 and 8, 1956; Conference Co-Chairmen, Robert P. Bauman, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. and Carl C. Clark, Naval Aviation Medical Acceleration Laboratory, Johnsville, Pa.

"Modern Ideas on Spontaneous Generation," December 26, 1956, held in collaboration with Section F, American Association for the Advancement of Science, Washington, D. C.; Chairman, Ross F. Nigrelli, New York Zoological Society, Zoological Park, The Aquarium, New York, N. Y.

"Immunology and Cancer," January 4 and 5, 1957, held in conjunction with the National Institutes of Health, Allergy and Immunology Study Section and National Cancer Institute, Public Health Service, Bethesda, Md.; Conference Chairman, Jerome T. Syverton, University of Minnesota Medical School, Minneapolis, Minn.

"Cellular Biology, Nucleic Acids and Viruses," January 7, 8 and 9, 1957. This conference was dedicated to and held in honor of Basil O'Connor, President, The National Foundation for Infantile Paralysis. Its organization and the development of the program were supported by a National Honorary Committee composed of 57 prominent persons throughout this country who represented many fields of academic learning and professional endeavor; a Local Steering Committee: Chairman, Joseph C. Hinsey, New York Hospital-Cornell Medical Center, New York, N. Y.; George E. Armstrong, New York University, New York, N. Y.; Marcus D. Kogel, Albert Einstein College of Medicine, Bronx, N. Y.; Howard W. Potter, State University of New York College of Medicine, Brooklyn, N. Y.; Aura E. Severinghaus, Faculty of Medicine, Columbia University, New York, N. Y.; Ralph E. Snyder, New York Medical College, Flower and Fifth Avenue Hospitals, New York, N. Y.; and Douglas M. Whitaker, The Rockefeller Institute for Medical Research, New York, N. Y.; a Program Committee: Chairman, Frank L. Horsfall, Jr., The Rockefeller Institute for Medical Research, New York, N. Y.; George B. Brown, Sloan-Kettering Institute for Cancer Research, New York, N. Y.; John G. Kidd, Cornell University Medical College, New York, N. Y.; Colin M. MacLeod, The University of Pennsylvania School of Medicine, Philadelphia, Pa.; Thomas M. Rivers, The National Foundation for Infantile Paralysis, New York, N. Y.; and Richard E. Shope, The Rockefeller Institute for Medical Research, New York, N. Y.; a Publication Committee: Chairman, Ross F. Nigrelli, The New York Academy of Sciences, New York, N. Y.; Morris Fishbein, Chicago, Ill.; Saul Lehman, The Georgian Press, New York, N. Y.; and Otto v. St. Whitelock, The New York Academy of Sciences, New York, N. Y.; and a Dinner Committee: Chairman, John M. Cotton, New York, N. Y.; Raymond H. Barrows, The National Foundation for Infantile Paralysis, New York, N. Y.; Margaret Eagan, New York, N. Y., and Eunice Thomas Miner, The New York Academy of Sciences, New York, N. Y.

"The Effects of the Sulfonylureas and Related Compounds in Experimental and Clinical Diabetes," February 14 and 15, 1957; Conference Chairman, Rachmiel Levine, Michael Reese Hospital, Chicago, Ill.

"Protein Nutrition," March 1 and 2, 1957, held in conjunction with E. I. du Pont de Nemours & Company, Wilmington, Del.; Conference Chairman, Fredrick J. Stare, Harvard University School of Public Health, Boston, Mass.; Organizing Committee: Chairman, Fredrick J. Stare; N. W. Flodin, E. I. du Pont de Nemours & Company, Wilmington, Del.; and D. M. Hegsted, Harvard University, Boston, Mass.

"Second Conference on Sulfonamides," March 22, 1957, Conference Chairman, Perrin H. Long, State University of New York School of Medicine, Brooklyn, N. Y.

"Comparative Clinical and Biological Effects of Alkylating Agents," March 28, 29, and 30, 1957, held in conjunction with the Cancer Chemotherapy National Service Center, Public Health Service, Bethesda, Md.; Conference Chairman, Leon H. Schmidt, The Christ Hospital Institute of Medical Research, Cincinnati, Ohio; Organizing Committee: Chairman, Leon H. Schmidt; F. Bergel, Chester Beatty Research Institute, Royal Cancer Hospital, London, England; M. Demerec, Carnegie Institution of Washington, Cold Spring Harbor, N. Y.; Alfred Gellhorn, Columbia University College of Physicians and Surgeons, New York, N. Y.; Alexander Haddow, Chester Beatty Research Institute, Royal Cancer Hospital, London, England; Byron Hall, Stanford University School of Medicine, San Francisco, Calif.; David A. Karnofsky, Sloan-Kettering Institute for Cancer Research, New York, N. Y.; F. S. Philips, Sloan-Kettering Institute for Cancer Research, New York, N. Y.; C. C. Price, University of Pennsylvania, Philadelphia, Pa.; C. C. Stock, Sloan-Kettering Institute for Cancer Research, New York, N. Y.; and Gordon Zubrod, National Cancer Institute, National Institutes of Health, Bethesda, Md.

"Animal Disease and Human Health," September 11, 12, and 13, 1957, held in conjunction with the U. S. Public Health Service, Communicable Disease Center, Atlanta, Ga.; Conference Chairman, James Lieberman, Communicable Disease Center, U. S. Public Health Service, Atlanta, Ga.; Organizing Committee: Chairman, James Lieberman; Robert L. Burkhart, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.; Thomas W. M. Cameron, McGill

University, Montreal, Canada; David L. Coffin, Speyer Hospital, New York, N.Y.; William H. Feldman, Mayo Foundation, Rochester, Minn.; William A. Hagan, New York State Veterinary College, Cornell University, New York, N. Y.; Morris Pollard, University of Texas Medical Branch, Galveston, Texas; and James H. Steele, U. S. Public Health Service, Atlanta, Ga.

"New Steroid Compounds with Progestational Activity," October 7 and 8, 1957, held conjointly with Parke, Davis & Company, Detroit, Mich.; G. D. Searle & Company, Chicago, Ill.; and E. R. Squibb & Sons, New York, N. Y.; Conference Co-Chairmen, Abraham E. Rakoff, Jefferson Medical College, Philadelphia, Pa., and Edward C. Reifenstein, Jr., The Squibb Institute for Medical Research, New York, N. Y.; Organizing Committee: Abraham E. Rakoff, Edward C. Reifenstein, Jr.; C. Lee Buxton, Yale University School of Medicine, New Haven, Conn.; J. William Crosson, G. D. Searle & Company, Chicago, Ill.; John E. Gajewski, Parke, Davis & Company, Detroit, Mich.; James H. Leathem, Rutgers University, New Brunswick, N. J.; and Warren O. Nelson, The Rockefeller Institute for Medical Research, New York, N. Y.

"The Development of High School Students toward Careers in Biology," October 18 and 19, 1957; Conference Co-Chairmen, George Schwartz, Forest Hills High School, Forest Hills, N. Y., and Leon Rintel, Forest Hills High School, Forest Hills, N. Y.; Organizing Committee: Chairman, Harry A. Charipper, New York University, New York, N. Y.; Ross F. Nigrelli, New York Zoological Society, Zoological Park, The Aquarium, New York, N. Y.; and George Schwartz, Forest Hills High School, Forest Hills, N. Y.

"Genetic Concept for the Origin of Cancer," October 25 and 26, 1957, held conjointly with the United States Public Health Service, National Advisory Cancer Council, National Institutes of Health, Bethesda, Md.; Conference Chairman Leonell C. Strong, Biological Station of Roswell Park Memorial Institute, Springville, N. Y.

In addition to these conferences, 435 meetings were held in the Academy Building during the past year. These not only covered Sectional meetings, conferences, Committee and Council meetings of the Academy, but 312 were those of 56 other societies to which the accommodations of the Building were extended.

The report of the Publication Committee giving the total of 5,371 pages published by the Academy in its *Annals* and *Transactions* series, as well as the figure of more than one million pieces of the Academy's literature distributed during the past year is well worthy of special attention. The staff members of the Editorial Division, the Publication Division, and of the Academy's Press are to be commended for their extensive efforts made this year on behalf of the publication schedule.

The membership of the Academy is keeping excellent pace with the momentum of this Society's activities. During the year ending October 31, 1957, 2,659 new Members were added to the rolls as follows: 1 Gold Card Member; 1 Patron; 11 Honorary Life Members; 3 Active Life Members; 80 Sustaining Members; 2,507 Annual Active Members; 54 Student Members; and 2 Corporation Members. Fifty-nine former Members were reinstated, thus making a total of 2,718 names added to the current membership rolls. Ten transfers were effected in the Annual classes, and 3 Annual Active Members transferred to Active Life Membership.

The Academy lost by death 4 Honorary Life Members, 5 Active Life Members, 8 Sustaining Members, and 44 Annual Active Members. Three hundred and ninety-seven resignations were accepted and 391 Members were dropped as not having paid dues or for not having qualified for membership.

The Academy now stands with a net gain of 1,869 Members for the current year. There are at present upon the rolls of the Academy 13,913 Members of whom 1,242 are Fellows, classified as follows:

1 Gold Card Member	396 Active Life Members
3 Benefactors	504 Sustaining Members
3 Patrons	12,803 Annual Active Members
69 Honorary Life Members	125 Student Members
	9 Corporation Members

Record is made with regret of the loss by death of the following Members:

Active Life Members

W. L. Hildburgh, elected to Life Membership, 2 October, 1922. Died December, 1956. Fellow.

Archer M. Huntington, elected to Life Membership, 30 March, 1945. Died 11 December, 1955. Fellow.

Charles C. Lieb, elected to Life Membership, 6 April, 1925. Died March, 1957. Fellow.

Raymond C. Osborn, elected to Life Membership, 8 April, 1929. Died 6 August, 1956. Fellow.

Bret Ratner, elected to Life Membership, 16 July, 1940. Died 11 October, 1957.

Sustaining Members

E. L. DeGolyer, elected to Sustaining Membership, 6 November, 1916. Died December, 1956. Fellow.

Ernest Kuss, elected to Sustaining Membership, 27 May, 1955. Died February, 1957.

Russell L. Laymon, elected to Sustaining Membership, 15 August, 1956. Died December, 1956.

Edward Mack, Jr., elected to Sustaining Membership, 15 June, 1951. Died 7 June, 1956.

Benjamin Salzer, elected to Sustaining Membership, 1 February, 1937. Died 12 November, 1956.

George Wagoner, elected to Sustaining Membership, 25 April, 1957. Died 29 April, 1957.

Leo Wallerstein, elected to Active Membership, January, 1916; transferred to Sustaining Membership, 27 October, 1938. Died December, 1956.

Carl V. Weller, elected to Sustaining Membership, 15 July, 1948. Died 10 December, 1956. Fellow.

Active Members

Emanuel M. Abrahamson, elected to Active Membership, 25 January, 1951. Died 19 March, 1956.

Sarkis J. Anthony, elected to Active Membership, 26 April, 1951. Died 3 December, 1956.

F. R. Beaudette, elected to Active Membership, 15 June, 1949. Died 17 January, 1957. Fellow.

Rhoda W. Benham, elected to Active Membership, 20 February, 1951. Died 19 January, 1957.

Ernest W. Blanchard, elected to Active Membership, 15 May, 1946. Died March, 1957.

Howard D. Borodkin, elected to Active Membership, 26 January, 1956. Died December, 1956.

Johannes Syrandt Buck, elected to Active Membership, 23 January, 1947. Died 9 August, 1956. Fellow.

Benjamin T. Burley, elected to Associate Membership, 6 February, 1939; transferred to Active Membership, 22 January, 1948. Died 16 May, 1956.

Emanuel S. Cohen, elected to Active Membership, 25 January, 1945. Died 31 May, 1957.

Martin Cooper, elected to Active Membership, 23 September, 1954. Died 21 March, 1957.

Eugene Davidoff, elected to Active Membership, 26 April, 1956. Died August, 1957.

Charles J. Duca, elected to Active Membership, 24 January, 1946. Died December, 1956.

Ludwig Ebert, elected to Active Membership, 15 December, 1952. Died November, 1956.

Joseph S. Friedman, elected to Active Membership, 6 May, 1940. Died May, 1956.

Morris Greenberg, elected to Active Membership, 25 April, 1946. Died 3 August, 1956. Fellow.

Jekuthiel Ginsberg, elected to Active Membership, 22 March, 1951. Died 8 October, 1957.

Louis Greenwald, elected to Active Membership, 24 April, 1947. Died 27 August, 1947.

John W. Hall, elected to Active Membership, 27 February, 1947. Died 19 March, 1957.

Siegwart Hermann, elected to Active Membership, 28 February, 1946. Died 27 November, 1956.

Hubert S. Howe, elected to Active Membership, 24 February, 1955. Died 4 February, 1957.

Frank Joseph Hynes, elected to Active Membership, 26 October, 1950. Died January, 1957.

Ottilie R. Inman, elected to Active Membership, 27 January, 1949. Died December, 1956.
Ernest Alfred Kellen, elected to Active Membership, 23 October, 1952. Died 4 March, 1953.
Roy H. Kienle, elected to Active Membership, 15 February, 1945. Died 2 September, 1957. Fellow.
William J. Lancaster, elected to Active Membership, 15 August, 1955. Died 26 April, 1957.
Irving Leinwand, elected to Active Membership, 15 September, 1949. Died 13 July, 1956.
Samuel Losner, elected to Active Membership, 13 August, 1953. Died 14 January, 1957.
Seymour Dewitt Ludlum, elected to Active Membership, 24 April, 1952. Died 2 December, 1956.
Edgar M. Medlar, elected to Associate Membership, 13 June, 1939; transferred to Active Membership, 22 March, 1945. Died 30 June, 1956.
Francesco Mogavero, elected to Active Membership, 15 September, 1955. Died July, 1956.
Carl Neuberg, elected to Active Membership, 14 June, 1946. Died 30 May, 1956. Fellow.
Kate Pelham Newcomb, elected to Active Membership, 15 June, 1955. Died December, 1956.
Bertha Ottenstein, elected to Active Membership, 22 April, 1954. Died November, 1956.
Louis Pillemer, elected to Associate Membership, 3 November, 1941; transferred to Active Membership, 24 January, 1946. Died 31 August, 1957. Fellow.
Henry W. Schoenlein, elected to Active Membership, 15 May, 1956. Died 7 July, 1957.
Bernard Smith, elected to Active Membership, 15 September, 1949. Died 14 January, 1957. Fellow.
Julius I. Steinfeld, elected to Sustaining Membership, 26 April, 1951; transferred to Active Membership, 24 April, 1952. Died August, 1956.
Raymond L. Thatcher, elected to Active Membership, 15 July, 1949. Died 15 May, 1957.
Emanuel Waldinger, elected to Active Membership, 27 October, 1955. Died March, 1957.
S. I. Weiner, elected to Active Membership, 15 December, 1954. Died July, 1957.
Albert Edward Wiggam, elected to Active Membership, 16 August, 1948. Died 26 April, 1957.
George B. Wislocki, elected to Active Membership, 13 July, 1951. Died 22 October, 1956. Fellow.
Gian Carlo Zorzoli, elected to Active Membership, 24 February, 1955. Died December, 1956.
Thomas L. Zuber, elected to Active Membership, 15 December, 1954. Died March, 1956.

Report of the Corresponding Secretary

There are, at present, upon the rolls of the Academy, 69 Honorary Life Members. The Corresponding Secretary takes this opportunity of presenting the Members of the Academy with an up-to-date list of the Honorary Life Membership Class:

Sven Olof Asplund ..... Gothenburg, Sweden
William Thomas Astbury ..... Leeds, England
Ernst David Bergmann ..... Tel Aviv, Israel
Charles Herbert Best ..... Toronto, Canada
Niels Bjerrum ..... Copenhagen Valby, Denmark
Niels Bohr ..... Copenhagen, Denmark
Henri Breuil ..... Paris, France
Sir MacFarlane Burnet ..... Victoria, Australia
Adolf F. J. Butenandt ..... Munich, Germany
M. Albert Caquot ..... Paris, France
Alfonso Caso ..... Mexico, D.F., Mexico
Maurice Caullery ..... Paris, France
Vere Gordon Childe ..... London, England
J. A. Christiansen ..... Copenhagen, Denmark
James Bertram Collip ..... London, Canada
Arthur H. Compton ..... St. Louis, Missouri
Charles Alfred Coulson ..... Oxford, England
Eduardo Cruz-Cole ..... Santiago, Chile
Henrique Da Rocha Lima ..... Sao Paulo, Brazil
Sir Henry Dale ..... London, England
Thomas Dalling ..... Rome, Italy
Clinton J. Davisson ..... Charlottesville, Virginia
Peter J. W. Debye ..... Ithaca, New York

Albert Defant	Innsbruck, Austria
Ulick R. Evans	Cambridge, England
Emmanuel Faure-Fremiet	Paris, France
Sir Howard Walter Florey	Oxford, England
Ross Granville Harrison	New Haven, Connecticut
Robert von Heine-Geldern	Grub, Austria
Sir David Kennedy Henderson	Edinburgh, Scotland
Corneille J. F. Heymans	Ghent, Belgium
Sir Cyril Norman Hinshelwood	Oxford, England
Bernardo A. Houssay	Buenos Aires, Argentina
Julian S. Huxley	London, England
Christopher Kelk Ingold	London, England
James Tutin Irving	Johannesburg, South Africa
Harold Jeffreys	Cambridge, England
Peter Kapitza	Moscow, U.S.S.R.
Vasant Ramj Khanolkar	Bombay, India
Alfred L. Kroeber	Berkeley, California
Hugo Rudolph Kruyt	The Hague, Holland
K. S. Lashley	Orange Park, Florida
Kaj U. Linderstrom-Lang	Copenhagen Valby, Denmark
Robert H. Lowie	Berkeley, California
Andre Lwoff	Paris, France
Gregorio Maranon y Posadillo	Madrid, Spain
Vladimir A. Obruchev	Moscow, U.S.S.R.
Marcus L. E. Oliphant	Canberra, Australia
Jean Piaget	Geneva, Switzerland
Henri Pieron	Paris, France
A. R. Radcliffe-Brown	Grahamstown, South Africa
Gaston Leon Ramon	Paris, France
Harold Herbert Read	London, England
Sir Robert Robinson	Great Missenden, Bucks, England
C. G. Rossby	Stockholm, Sweden
John A. M. Runnstrom	Stockholm, Sweden
Henry Norris Russell	Princeton, New Jersey
H. Schaefer	Heidelberg, Germany
Adolph H. Schultz	Zurich, Switzerland
Wilson Smith	London, England
Erik A. Stensio	Stockholm, Sweden
Th. Svedberg	Uppsala, Sweden
Nicholas H. Swellengrebel	Amsterdam, Holland
Albert Szent-Gyorgyi	Woods Hole, Massachusetts
Arne Tiselius	Uppsala, Sweden
Felix A. Vening-Meinesz	Anersfoort, Holland
Henri Rene Villat	Paris, France
Max Von Laue	Berlin, Germany
M. S. Watson	London, England

Record is made with regret of the death of the following Honorary Life Members:

Karl Friedrich Bonhoeffer, Berlin, Germany, elected December 6, 1956, died May 15, 1957.

Irving Langmuir, Schenectady, New York, elected December 14, 1938, died August 16, 1957.

Harald U. Sverdrup, Oslo, Norway, elected December 15, 1942, died August 21, 1957.

Rudolf Weigl, Sebastiana, Cracow, Poland, elected December 15, 1948, died August 11, 1957.

Report on the Status of Publications

During the fiscal year ending October 31, 1957, The New York Academy of Sciences has published 23 monographs, comprising a total of 4,601 pages. Included in these are 391 papers by 653 authors. The pagination of the *Transactions* (770) brings the total pagination issued to 5,371 pages. The list of publications issued during the fiscal year is as follows:

Annals

Volume 65, Article 4. *Techniques for the Study of Behavioral Effects of Drugs* (8 papers), by Peter B. Dews *et al.* Pages 247-356. Published November 2, 1956.

Volume 64, Article 4. *Experimental Methods for the Evaluation of Drugs in Various Disease States* (26 papers), by Bradford N. Craver *et al.* Pages 463-732. Published November 16, 1956.

Volume 67, Article 5. *The Evaluation of Autonomic Responses: Toward a General Solution* (1 paper), by John I. Lacey. Pages 123-164. Published November 30, 1956.
Volume 67, Article 6. *Recent Applications of Electron Diffraction* (1 paper), by J. J. Trillat. Pages 165-184. Published December 26, 1956.
Volume 67, Article 7. *The Use of Certain Sulfonamides in the Treatment of Experimental Diabetes Mellitus* (1 paper), by Auguste Loubatières. Pages 185-206. Published December 28, 1956.
Volume 66, Article 3. *The Pharmacology of Psychotomimetic and Psychotherapeutic Drugs* (35 papers), by Seymour S. Kety *et al.* Pages 417-840. Published March 14, 1957.
Volume 64, Article 5. *Second Tissue Homotransplantation Conference* (30 papers), by John Marquis Converse *et al.* Pages 735-1073. Published March 22, 1957.
Volume 66, Article 4. *Anesthesiology and Related Problems* (16 papers), by C. R. Stephen *et al.* Pages 841-1022. Published April 2, 1957.
Volume 65, Article 5. *Mercury and Its Compounds* (24 papers), by Cecil V. King *et al.* Pages 357-652. Published April 11, 1957.
Volume 67, Article 8. *Viruses in Search of Disease* (20 papers), by Robert J. Huebner *et al.* Pages 209-446. Published April 19, 1957.
Volume 67, Article 10. *Meprobamate and Other Agents Used in Mental Disturbances* (24 papers), by Frank M. Berger *et al.* Pages 671-894. Published May 9, 1957.
Volume 67, Article 11. *Man-Made Fiber Progress* (9 papers), by J. J. Press *et al.* Pages 897-982. Published May 24, 1957.
Volume 67, Article 9. *Unstable Chemical Species: Free Radicals, Ions, and Excited Molecules* (16 papers), by Henry C. Thacher, Jr. *et al.* Pages 447-670. Published May 24, 1957.
Volume 71, Article 1. *The Effects of the Sulfonylureas and Related Compounds in Experimental and Clinical Diabetes* (35 papers), by Rachmiel Levine *et al.* Pages 1-292. Published July 10, 1957.
Volume 65, Article 6. *The Electrophysiology of the Heart* (34 papers), by Hans H. Hecht *et al.* Pages 653-1146. Published August 9, 1957.
Volume 71, Article 2. *Determination of Sr^{90} and Ba^{140} in Bone, Dairy Products, Vegetation, and Soil* (1 paper), by H. L. Volchok *et al.* Pages 293-304. Published August 28, 1957.
Volume 69, Article 2. *Modern Ideas on Spontaneous Generation* (12 papers), by Ross F. Nigrelli *et al.* Pages 255-376. Published August 30, 1957.
Volume 68, Article 1. *Proteolytic Enzymes and Their Clinical Application* (22 papers), by Gustav J. Martin *et al.* Pages 1-244. Published August 30, 1957.
Volume 70, Article 1. *The Role of I^{131}-Labeled Proteins in Biology and Medicine* (13 papers), by S. P. Masouredis *et al.* Pages 1-152. Published August 30, 1957.
Volume 69, Article 1. *Biological Applications of Infrared Spectroscopy* (16 papers), by Robert P. Bauman *et al.* Pages 1-254. Published September 7, 1957.
Volume 71, Article 3. *Transplantation of Fins in Xiphophorin Fishes* (1 paper), by Klaus D. Kallman and Myron Gordon. Pages 305-320. Published September 9, 1957.
Volume 69, Article 3. *Second Conference on Sulfonamides* (18 papers), by Perrin H. Long *et al.* Pages 377-524. Published October 12, 1957.
Volume 68, Article 2. *Subcellular Particles in the Neoplastic Process* (28 papers), by Cornelius P. Rhoads *et al.* Pages 245-656. Published October 21, 1957.

In addition to the publications cited above, the following monograph was published during November 1957, after the close of the fiscal year:

Special Publications of The New York Academy of Sciences, Volume V. *Cellular Biology, Nucleic Acids, and Viruses* (29 papers), by Thomas M. Rivers *et al.* Pages 1-414. Published November 14, 1957.

Transactions

Series II, Volume 19, Numbers 1 to 8, consisting of 770 pages, covering the period from November 1956 to June 1957, inclusive, was completed, printed and, distributed during the calendar year.

Annals in Press

Volume 69, Article 4. *Immunology and Cancer* (29 papers), by Jerome T. Syverton *et al.* Awaiting publication December 9, 1957.
Volume 70, Article 2. *Structural Design Study for Radio Telescope with 600-Foot Diameter Paraboloid Reflector* (1 paper), by Jacob Feld. Accorded the D. B. Steinman Award in 1955. Awaiting publication December 6, 1957.
Histochemical and Microchemical Observations on the Lipids of the Interscapular Brown Fat of the Female Vespertilionid Bat, Myotis lucifugus lucifugus (1 paper), by Guy-Laurent Rémillard. Accorded an A. Cressy Morrison Award in Natural Sciences in 1956. Awaiting publication by Academy press.
The Paramagnetic Resonance and Optical Spectra of Some Ions in Cubic Crystalline Fields (1 paper), by W. Low. Accorded an A. Cressy Morrison Award in Natural Sciences in 1956. Awaiting publication by Academy press.
Recent Studies on the Epidemiology of Histoplasmosis (1 paper), by M. L. Furcolow. Awaiting publication by Academy press.

Volume 69, Article 5. *Protein Nutrition.* In page proof.
Volume 68, Article 3. *Comparative Clinical and Biological Effects of Alkylating Agents.* Awaiting galley proof.
Animal Disease and Human Health. Monograph sent to printer November 27, 1957.
Chlorothiazide and Other Diuretic Agents. Monograph sent to printer December 4, 1957.

From November 1, 1956, to October 31, 1957, the Academy distributed 1,151,412 separate publications of the various series as follows:

Distribution of Publications
11/1/56 to 10/31/57

	Separate Numbers
Annals	
Members	101,116
Gratis: Authors, reviews, exchanges, and donors	12,399
Sales	314,156
Authors reprints	492,450
Transactions	
Members	103,746
Gratis: Authors, exchanges, review	3,411
Sales	1,174
Authors reprints	15,850
Special Publications, Volume I, III, IV	
Sales	72
Scientific Survey of Porto Rico and the Virgin Islands	
Gratis	10
Sales	175
Monthly Program	
Members	103,480
Sales	1,769
Gratis: Individuals	1,604
	1,151,412

In addition to sales, the total *list* value of those publications distributed to the Members, and gratis to authors, donors, reviews, and exchange institutions is $494,917.76.

Report of the Treasurer

This report of the Treasurer on the financial status of the Academy is supported by the accompanying statements of the Auditors covering the Balance Sheet of Assets and Liabilities, in addition to the statement of Income and Expense, thus clearly indicating the financial position of the Academy as of October 31, 1957, the closing date of the fiscal year.

The gross income, both for operating and capital funds, is higher than that for 1956, and the closing figures reveal that in all categories, except for grants-in-aid, the Academy has improved its financial status in spite of the rising costs and the increase in the many demands upon this organization's services and resources.

The capital and operating assets combined ended as at October 31, 1957 with a total of $1,192,074.10, a net increase of $44,569.86 over the closing

figures of $1,147,504.24 for 1956. The gross increase of income, $55,324.41, is reflected in the several categories of the funds as follows:

General Fund (operating)	$16,143.02
Endowment Funds	34,262.41
Building Fund	4,384.84
Prize Funds	534.14
	$55,324.41

The general operating fund surplus increased from $5,791.11 to $14,746.92, even though the deduction of $8,253.79 was made from general funds to cover the reduction of payments on the mortgage principal.

The unusual increase in sales of publications is largely due to the many excellent conferences held during 1956 and 1957; to a determined effort to bring the publication schedule up to date; and to an accelerated sales promotion campaign that has been carried on by the Academy's staff with an aim toward developing a livelier interest in the value to science of these publications.

The Academy is deeply grateful for the increase in income derived from the continued growth in membership and, in turn, makes every effort to give a return in privileges and service so as to make membership in the Academy worthwhile and desirable.

While these two activities, membership support and sales of publications, constitute the main sources of income for carrying on the Academy's work, there are other important factors that do not directly show on the Balance Sheet, but are essential to its condition of well-being and improvement. There are the contributions of the many hundreds of scientists who present the results of their researches of outstanding caliber to the meetings and for inclusion in the publications; to the officers who give voluntarily and generously of their time and valuable experience for the government of the Academy; and to the employed staff that works with loyalty and concentrated effort for the successful economic management of the monies and activities of this organization.

The expression "these are things that money cannot buy" effectively applies to the latter sources of support for, unquestionably, these are among the important contributions toward the continued financial growth of the Academy.

While an optimistic picture of the financial condition of the Academy is being presented as at the close of the fiscal year 1957, it should be realized that a never-ending struggle is required to maintain this financial position. To carry on its work with the necessary funds for its success, the Academy, like all other philanthropic institutions without a large endowment, must renew its endeavor annually to obtain its main sources of income from the renewals and increased growth of membership; the distribution of its publications; and whatever support may be obtained in grants-in-aid from outside sources.

The books of accounting have been checked and audited by the firm of Peat, Marwick, Mitchell & Company, Certified Public Accountants. The property of the Academy has been verified by the Auditors and by the Finance Committee of the Academy.

The report of the Auditors has been approved by the Finance Committee as of November 26, 1957, as provided in the Bylaws.

Report of the Auditors

PEAT, MARWICK, MITCHELL & CO.
Certified Public Accountants
Seventy Pine Street
New York 5, N. Y.

Accountants' Report

The Finance Committee,
The New York Academy of Sciences:

We have examined the balance sheet of The New York Academy of Sciences as of October 31, 1957 and the related statement of general fund income and expenses and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

The cash has been confirmed by certificate obtained directly from the depositary or by count. The cash held by J. R. Williston & Co., carried for the purchase of securities, has been confirmed by acknowledgment from the custodian.

We did not confirm the members' dues or the pledges receivable by communication with the respective members or pledgers. We communicated with all debtors on miscellaneous accounts receivable, representing charges for publications, use of building, etc., by mailing the Academy's statements for the month of October accompanied by a request that we be notified of any exceptions. The exceptions reported were explained to our satisfaction. Provision has not been made for possible loss in collection of receivables.

The inventory of the printing division is stated in accordance with a physical inventory taken and valued by employees of the Academy and certified by the Executive Director as to description, quantities, condition and valuation. We made tests of the quantities, prices and computations. The balance sheet does not reflect the books and publications on hand at October 31, 1957, as it is the policy of the Academy to charge publication costs to expense as incurred.

The marketable securities were inspected or confirmed by the custodian and the income therefrom was confirmed by reference to independent sources.

We inspected the deed to the real estate at Two East 63rd Street, New York, N.Y., contributed to the Academy in 1949. It is carried in the balance sheet at the valuation, $425,000.00, as assessed by the City of New York for real estate tax purposes as of the date of the contribution, plus the cost of improvements. Furniture, fixtures and equipment acquired by the Academy, through purchase or contribution, are not reflected in the assets; the purchases during the year ended October 31, 1957 have been charged to the income of the general fund. In conformity with the practice usually followed by similar organizations, the Academy does not provide for depreciation of the building and improvements.

All liabilities of which we obtained knowledge as a result of our examination have received appropriate recognition.

In our opinion, subject to the foregoing comments, the accompanying balance sheet and statement of general fund income and expenses and surplus present fairly the financial position of The New York Academy of Sciences at October 31, 1957 and the results of its operations for the year then ended on a basis consistent with that of the preceding year.

s/ PEAT, MARWICK, MITCHELL & CO.

New York, N. Y.
November 21, 1957

THE NEW YORK ACADEMY OF SCIENCES

Comparative Balance Sheet

October 31, 1957 and 1956

ASSETS

	1957	1956
General Fund		
Cash	$ 6,620.19	13,159.77
Receivables: Members' dues	8,535.00	7,605.00
Miscellaneous accounts	21,229.16	12,601.26
Inventory – printing division	17,318.33	5,150.23
Prepaid expenses	2,090.49	1,133.89
	$ 55,793.17	39,650.15
Endowment Funds		
Cash deposited with J. R. Williston & Co.	$ 24,511.53	57,426.87
Marketable securities – stated at purchase cost or quoted price at date of contribution (quoted market value at October 31, 1957, $475,717.00)	543,546.35	476,368.60
	$568,057.88	533,795.47
Building Fund		
Cash	$ 1,026.69	79.94
Receivables – pledges	1,370.00	1,422.50
Marketable securities – stated at purchase cost or quoted price at date of contribution (quoted market value at October 31, 1957, $17,851.25)	18,108.63	14,618.04
Real estate at 2 East 63rd Street, New York, N.Y., at assessed valuation at date of contribution, and improvements ($27,280.63) at cost	452,280.63	452,280.63
	$472,785.95	468,401,11
Prize Funds		
Cash	$ 3,422.52	2,888.38
Marketable securities – stated at purchase cost or quoted price at date of contribution (quoted market value at October 31, 1957, $16,803.25)	16,546.79	16,546.79
	$ 19,969.31	19,435.17
Special Funds		
Cash	$ 66,891.25	81,579.30
Receivables – miscellaneous accounts	8,576.54	2,821.00
Due from endowment funds	– –	1,822.04
	$ 75,467.79	86,222.34

THE NEW YORK ACADEMY OF SCIENCES

Comparative Balance Sheet — *Continued*

October 31, 1957 and 1956

LIABILITIES AND FUNDS

	1957	*1956*
General Fund		
Liabilities:		
Accounts payable	$ 2,637.62	— —
Mortgage interest accrued, at rate of 4½% per year	1,085.46	1,147.36
Members' dues unearned	35,403.17	30,056.68
Members' dues collected in advance	1,920.00	2,655.00
Fund surplus, per accompanying statement	14,746.92	5,791.11
	$ 55,793.17	39,650.15
Endowment Funds		
Principal of funds:		
John James Audubon Fund	$ 2,500.00	2,500.00
Nathaniel Lord Britton Fund	30,039.77	30,039.77
Centennial Endowment Fund	7,934.00	7,934.00
Roy Waldo Miner Memorial Publication Fund	7,123.00	6,893.00
John Strong Newberry Fund	1,000.00	1,000.00
George H. Sherwood Memorial Fund	7,000.00	7,000.00
Ralph Winfield Tower Memorial Fund	12,728.00	12,728.00
Thomas Lincoln Casey Fund	213,461.99	213,461.99
John Roger Fund	1,000.00	1,000.00
Capital gains and losses (net) on investment transactions, reserved	285,271.12	249,416.67
	568,057.88	531,973.43
Due to special funds	— —	1,822.04
	$568,057.88	533,795.47
Building Fund		
Mortgage (balance of principal; original amount, $200,000.00) on real estate (payable $3,750.00 quarterly for principal and interest, and balance due November 1, 1959)	$144,728.30	152,982.09
Principal of fund	328,057.65	315,419.02
	$472,785.95	468,401.11
Prize Funds		
Principal of funds:		
George Frederick Kunz Prize Fund	$ 1,393.68	1,344.01
A. Cressy Morrison Prize Fund	18,575.63	18,091.16
	$ 19,969.31	19,435.17
Special Funds		
Principal of funds:		
Grants-in-aid	$ 68,199.28	78,347.60
New York Society of Electron Microscopists	— —	1,153.61
Contributions:		
Women's Auxiliary	573.06	2,362.39
Furniture and fixtures	66.15	176.15
Auditorium project fund	115.07	110.82
Unexpended investment income of endowment funds	6,514.23	4,071.77
	$ 75,467.79	86,222.34

THE NEW YORK ACADEMY OF SCIENCES

Statement of General Fund Income and Expenses and Surplus
Year ended October 31, 1957

Income:		
Membership dues		$202,612.51
Sales of publications		259,469.20
Contributions-in-aid		117,267.93
Contributions — use of building facilities		36,722.08
Contributions to general fund		521.00
Income from securities of endowment and building funds		25,214.49
		641,807.21
Expenses:		
Publication costs (including salaries and expenses of printing division)	$254,777.59	
Distribution of publications	19,633.66	
Postage	23,396.57	
Use of building, conferences and meetings expenses	124,529.64	
Building operating salaries and expenses	49,693.98	
Executive salaries and expenses	30,774.47	
Editorial staff — salaries and expenses	49,180.34	
Membership expansion — salaries and expenses	18,186.19	
Public relations — salaries and expenses	8,402.82	
Societies administration	12,725.78	
Social security taxes	3,694.25	
Interest on mortgage	6,684.31	
Accounting salaries and expenses	8,306.73	
General office salaries and expenses	14,611.28	624,597.61
Excess of income over expenses for year		17,209.60
General fund surplus at October 31, 1956		5,791.11
		23,000.71
Deduct:		
Contribution from general fund to building fund — equivalent to the payments of mortgage principal		8,253.79
General fund surplus at October 31, 1957		$ 14,746.92

Election of Fellows and Honorary Life Members

The following Members were elected to Fellowship:

Addinal, Carl R., Ph.D.
Alving, Alf Sven, M.D.
Amis, Edward S., Ph.D.
Arnold, Richard T., Ph.D.
Ashley, Samuel E. Q., M.A.
Bailey, Charles Philamore, M.D.
Bailey, Pearce, M.D.
Baker, Burton L., Ph.D.
Balazs, Endre A., M.D.
Berend, Gertrude, Ph.D.
Berry, Levette Joe, Ph.D.
Beyler, Arthur L., Ph.D.
Bieber, Samuel, Ph.D.
Bierman, Howard Richard, M.D.
Black, Maurice M., M.D.
Bloch, Herman S., Ph.D.
Bohonos, Nestor, Ph.D.
Boord, Cecil E., Ph.D.
Borst, Lyle, Ph.D.
Breedis, Charles, M.D.

Brehm, Warren J., Ph.D.
Breit, Gregory, Ph.D.
Brody, Henry, M.D.
Brown, Dugald E. S., Ph.D.
Brown, Ethan Allan, M.D.
Brown, Rachel, Ph.D.
Bruger, Maurice, M.D.
Brunst, Victor V., D.Sc.
Burkhart, Robert L., D.V.M.
Carter, Anne Cohen, M.D.
Chase, Merrill W., Ph.D.
Cheronis, Nicholas D., Ph.D.
Clark, Leland C., Jr., Ph.D.
Clark, R. Lee, Jr., M.D.
Cohen, Herman, Ph.D.
Collins, Donald C., M.D.
Conn, Hadley L., Jr., M.D.
Cooke, Robert A., M.D.
Cooper, Irving S., Ph.D.
Corcoran, Arthur C., M.D.
Crane, Jocelyn, M.Sc.
Crick, Francis Harry Compton, Ph.D.
Day, Allan R., Ph.D.
Day, Jesse Harold, Ph.D.
Dembowski, Jan, Ph.D.
DeNavarre, Maison G., Ph.D.
Denouette, Rene Edy, LL.M., LL.D.
Diamond, Henry David, M.D.
Dohan, F. Curtis, M.D.
Dougherty, Ellsworth C., M.D.
Durrum, Emmett L., M.D.
Dury, Abraham, Ph.D.
Eichna, Ludwig W., M.D.
Engel, Frank L., M.D.
Finch, Stuart C., M.D.
Foshay, Lee, M.D.
Fraenkel-Conrat, Heinz L., Ph.D.
Freedman, Henry H., Ph.D.
Fruhman, George Joshua, Ph.D.
Fuhrman, Frederick A., Ph.D.
Fulton, John F., M.D.
Gemeroy, Douglas G., Ph.D.
Gesler, Robert M., Ph.D.
Giguere, Paul A., Ph.D.
Griffith, Wendell, Ph.D.
Grinker, Roy R., M.D.
Gross, Jack, Ph.D.
Gross, Ludwik, M.D.
Haagen-Smit, Arie F., Ph.D.
Halberg, Franz, M.D.
Halford, Ralph S., Ph.D.
Halstead, Bruce W., M.D.
Hammond, Edward Cuyler, D.Sc.
Hampton, Stanley F., M.D.
Harkavy, Joseph, M.D.
Haskins, Edna Ferrell, Ph.D.
Helpern, Milton, M.D.
Hesser, Frederick Harrison, M.D.
Hill, Henry Eric, E.E.
Hinton, Taylor, Ph.D.
Hiscock, Ira V., Sc.D.
Hodgson, George S., M.D.
Hoff, Ebbe C., M.D.
Hollomon, John Herbert, Ph.D.
Holt, Joseph Paynter, Ph.D.
Hoobler, Sibley W., D.Sc.
Huebner, Robert J., M.D.
Huff, Rex L., M.D.
Inch, Robert Stuart, M.R.C.P.E.
Ingelfinger, Franz J., M.D.
Janeway, Charles A., M.D.
Johnson, Willis H., Ph.D.
Johnston, Franklin Davis, M.D.
Johnstone, Herbert G., Ph.D.
Kallman, Robert F., Ph.D.
Kass, Edward H. M.D.
Katchalsky, Aaron, Ph.D.
Keosian, John, Ph.D.
Kharasch, Norman, Ph.D.
Kirschbaum, Arthur, M.D.
Kleinholz, Lewis H., Ph.D.
Knaysi, Georges A., Ph.D.
Kohlstaedt, Kenneth G., M.D.
Kosak, Alvin I., Ph.D.
Kossmann, Charles E., M.D.
Kountz, William B., M.D.
Kudo, Richard R., D.Sc.
Kuhn, Richard, Ph.D.
Kulp, J. Laurence, Ph.D.
Lange, Jack D., M.D.
Lange, Kurt, M.D.
Lazzarini, Abel Alfred, Jr., M.D.
Lederer, Edgar, Ph.D.
Leiter, Louis, Ph.D.
Lepore, Michael J., M.D.
Lev, Maurice, M.D.
Lincicome, David Richard, Ph.D.
Loomis, W. Farnsworth, M.D.
Lutz, Brenton Reid, Ph.D.
Ma, T. S., Ph.D.
Malherbe, Willem Daniel, B.V.Sc.
Mangun, George Harold, Ph.D.
McCann, William S., M.D.
Megel, Herbert, Ph.D.
Meglitsch, Paul, Ph.D.
Mider, G. Burroughs, M.D.
Miller, C. Phillip, M.D.
Minatoya, Hiroaki, M.S.
Morowitz, Harold, J., Ph.D.
Mrak, E.M., Ph.D.
Myers, Jack Duane, M.D.
Namias, Jerome, M.S.
Natta, Giulio, Dr. Chem. Eng.
Newman, Elliot V., M.D.
Oppenheim, Abraham, M.D.
Oriani, Richard A., Ph.D.
Overman, Richard R., Ph.D.
Padawer, Jacques, Ph.D.
P'an, Shih-Yi, M.D.
Pankratz, David S., M.D.
Piel, Gerard, A.B.
Piliero, Sam Joseph, Ph.D.
Reynolds, Orr E., Ph.D.
Richards, Oscar W., Ph.D.
Rinzler, Seymour H., M.D.
Roberts, John D., Ph.D.
Rockwell, Harriet E., Ph.D.

Romanoff, Alexis L., Ph.D.
Rose, Bram, M.D.
Rosenberg, Hans R., Sc.D.
Ross, Joseph F., M.D.
Salm, Heinz, M.D.
Sanders, Murray, M.D.
Schwartz, George L., B.A.
Seaman, Gerald R., Ph.D.
Selke, William A., D. Eng.
Shefferman, Maurice, D. Optom.
Shock, Nathan W., Ph.D.
Shore, Maurice J., Ph.D.
Shuster, Carl N., Jr., D.Sc.
Slim, J. Chr., M.D.
Sokoloff, Leon, M.D.
Sonenberg, Martin, M.D.
Sowden, John C., Ph.D.
Spar, Jerome, Ph.D.
Sparrow, A. H., Ph.D.
Speirs, Robert S., Ph.D.
Sponer, Hertha D. E., Ph.D.
Stb, Adrian Morris, Ph.D.
Stefanini, Mario, Ph.D.
Stoll, Max, D.Sc.
Stunkard, Albert James, M.D.
Tapley, Mark W., Ph.D.
Thomas, Lewis, M.D.
Tolles, Walter Edwin, M.S.
Treat, Asher E., Ph.D.
Tullis, James Lyman, M.D.
Unna, Klaus R., M.D.
Van Rysselberghe, Pierre, Ph.D.
Van Zyl, Gerrit, Ph.D.
Varga, Laszle, Ph.D.
Velardo, Joseph Thomas, Ph.D.
Wallerstein, Harry, M.D.
Weinstein, Marvin J., Ph.D.
Weissenberg, Richard, M.D.
Whipple, Fred L., Ph.D.
Wilkins, Robert W., M.D.
Wilson, Armin Guschel, Ph.D.
Wolf, Maurice E., M.D.
Wolfrom, Melville L., Ph.D.
Wolken, Jerome J., Ph.D.
Wright, Arthur W., M.D.
Wright, George F., Ph.D.
Wulff, Verner J., Ph.D.
Zaffaroni, Alejandro, Ph.D.

Honorary Life Memberships were conferred upon the following eminent scientists:

Peter Brian Medawar, University College, London, England.
Francis John Worsley Roughton, Cambridge University, Cambridge, England.
Gerhard Schramm, Max Planck Institute for Virus Research, Tübingen, Germany.

Election of Officers

REPORT OF THE TELLERS

The tellers appointed by President Nigrelli to count the ballots for the election of Officers and other Members of the Council to serve for the year 1958 report that the names on the Official Ballot, as printed and distributed, were elected by the votes of the 2,555 ballots returned by the Membership.

The list thus chosen by the Membership of the Academy for the year 1958 is as follows:

President-Elect
HILARY KOPROWSKI

Vice-Presidents
M. J. KOPAC C. P. RHOADS

Recording Secretary
EMERSON DAY

Corresponding Secretary
FREDERICK C. NACHOD

Treasurer
ROBERT F. LIGHT

Councilors (1958-1960)
DAVID A. KARNOFSKY
GUSTAV J. MARTIN
WAYNE W. UMBREIT
JOHN E. VANCE

Finance Committee
HARDEN F. TAYLOR, *Chairman*
GORDON Y. HILLARD JOHN TEE-VAN

Chairmen of Sections
KURT E. LOWE, *Geology and Mineralogy*
ALBERT S. GORDON, *Biology*
ELAINE R. GRIMM, *Psychology*
MARGARET MEAD, *Anthropology*
JOSEPH GREENSPAN, *Physics and Chemistry*
ABRAHAM S. KUSSMAN, *Oceanography and Meteorology*
LYLE BORST, *Mathematics and Engineering*

Chairman of Division
M. L. LITTMAN, *Mycology*

Awards for 1957

(1) *The A. Cressy Morrison Awards in Natural Science.* After careful consideration and comparison of the eligible papers presented in competition this year, the Committee unanimously made the following awards:

An award of $400 to Savino A. D'Angelo and Ronald E. Traum, The Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia, Pa., for the paper *An Experimental Analysis of the Hypothalamic-Hypophysial-Thyroid Relationship in the Rat.*

An award of $400 to Margaret A. Kelsall and Edward D. Crabb, Department of Biology, University of Colorado, Boulder, Colo., for the paper *Lymphocytes and Plasmacytes in Nucleoprotein Metabolism.*

Honorable mention to Raymond R. Myers and William H. Chandler, Chemistry Laboratory, Lehigh University, Bethlehem, Pa., for the paper *Quantum Aspects of Catalysis. I. Oxidations and Other Reactions of Ethylene.*

Honorable mention to George C. Cotzias and James J. Greenough, Medical Department, Brookhaven National Laboratory, Associated Universities Inc., Upton, L. I., N. Y., for the paper *The High Specificity of the Manganese Pathway in the Body.*

(2) *The Boris Pregel Award in the Field of Natural Radioactive Substances.* Since no paper completely fulfilling the conditions for competition was presented to the Academy during 1957, the Committee made no award in this field.

(3) *The D. B. Steinman Award for Research in Structural Engineering.* An award of $500 to Thomas C. Kavanagh, Praeger-Kavanagh, Engineers, New York, N. Y., for the paper *Rational Simplifications for the Buckling Lengths of Columns.*

Abstracts of 1957 Award Papers

AN EXPERIMENTAL ANALYSIS OF THE HYPOTHALAMIC-HYPOPHYSIAL-THYROID RELATIONSHIP IN THE RAT

By Savino A. D'Angelo and Ronald E. Traum*

Accorded an A. Cressy Morrison Award in Natural Science, 1957

An analysis of the rat's hypothalamic-hypophysial-thyroid system has been made, utilizing a combination of stereotactic, radiometric, histochemical and bioassay procedures. The experimental results indicate

*The Daniel Baugh Institute of Anatomy, The Jefferson Medical College, Philadelphia, Pa.

that the hypothalamus modulates the activity of the pituitary-thyroid system by influencing production and release of TSH from the basophils (beta) of the adenohypophysis. The regulation of TSH secretion exists for normal conditions as well as for those in which augmentation of hormone secretion is required. The servomechanism between thyroid and hypophysis is not under hypothalamic domination, but is systemically controlled by the circulating level of thyroid hormone; the latter inhibits TSH secretion at the adenohypophysis without mediation of the hypothalamus. The cytophysiologic changes that ensued in the adenohypophyses of hypothalamically lesioned rats, the selective impairment in target gland morphology, and the subsequent differential response of these glands to hormonal treatment (thyroid) were such as to suggest the presence of individual, discriminative hypothalamic-hypophysial mechanisms in the regulation of trophic hormone secretion.

LYMPHOCYTES AND PLASMACYTES IN NUCLEOPROTEIN METABOLISM

By Margaret A. Kelsall and Edward D. Crabb*

Accorded an A. Cressy Morrison Award in Natural Science, 1957

This paper presents a working hypothesis holding that the function of the small lymphocyte is to synthesize, store, and transport nucleoproteins for use by other cells, and that the function of the plasmacyte is to synthesize and store RNA and gamma-globulins, instead of having only the delimited function of producing antibodies. The size, motility, mobility, ubiquitous distribution, absence of mitosis, high nucleocytoplasmic ratio, and rapid turnover are characteristics that enable small lymphocytes to function as trephocytes. Small lymphocytes within columnar epithelial cells of intestinal villi are considered intracellular trephocytes and not as being in the process of elimination.

Plasmacytes, which likewise do not divide, develop from lymphocytes in normal animals in the lymph nodes, spleen, hemolymph nodes, and tunica propria of the intestine. These organs and tissues are characterized by partial stasis of fluid containing abnormally large amounts of plasma proteins. The lymph nodes store nucleoproteins between tissue fluid and blood stream, whereas the spleen and possibly hemolymph nodes regulate and store protein within the blood vascular system. Peyer's patches, solitary follicles, the vermiform appendix of rabbits, and small lymphocytes and plasmacytes in the other regions of the intestinal mucosa synthesize and store amino acids and nucleoproteins between the lumen of the intestine and the blood and lymph.

*Department of Biology, University of Colorado, Boulder, Colo.

Lysis of small lymphocytes and plasmacytes in the hepatic portal vein, spleen, mesenteric lymph nodes, mucosa of the intestine, and in other preportal organs may be related to protein synthesis in the liver.

Infiltrations of small lymphocytes and plasmacytes in areas of wound healing and chronic inflammation concentrate proteins for use by other cells in regenerating or replacement processes. Infiltrations of these cells indirectly antagonize growth of heterologous tumor transplants by stimulating fibrocytogenesis in the host.

RATIONAL SIMPLIFICATIONS FOR THE BUCKLING LENGTHS OF COLUMNS

By Thomas C. Kavanagh*

Accorded a D. B. Steinman Award for Research in Structural Engineering, 1957

Most contemporary structural specifications (and particularly those for structural steel) omit any reference to effective lengths of columns, thereby assuming a constant buckling length equal to the actual column length for all types of columns. That this can lead to serious overdesign on the one hand, or hazardous underdesign on the other, is evidenced by the fact that a fixed slender column will carry four times the load of an identical pin-ended column before buckling, while a "flagpole column" will carry only one fourth the pin-ended load. The situation is far more serious than this, however; a column may actually have a buckling length as much as infinitely larger than its actual length, depending upon its end restraints.

THE NEW YORK ACADEMY OF SCIENCES

announces

FIVE SCIENTIFIC AWARDS FOR 1958

The New York Academy of Sciences announces the following five awards for the coming year.

I. THE A. CRESSY MORRISON AWARDS IN NATURAL SCIENCE

Two awards of $400 each, to be known as THE A. CRESSY MORRISON AWARDS IN NATURAL SCIENCE, will be announced at the Annual Meeting of The New York Academy of Sciences in December 1958 for the two most acceptable papers in a field of science covered by the Academy or an Affiliated Society.

II. THE GEORGE FERDERICK KUNZ AWARD IN GEOLOGY AND MINERALOGY

An award of $400 offered in accordance with the bequest of the late George Frederick Kunz, designated as the GEORGE FREDERICK KUNZ AWARD IN GEOLOGY AND MINERALOGY, will be made for the most acceptable paper in

*Praeger-Kavanagh, Engineers, New York, N. Y.

the field of geology and/or mineralogy for the year 1958. This award will be announced at the Annual Meeting of the Academy in December 1958.

III. THE BORIS PREGEL AWARD IN THE FIELD OF NATURAL RADIOACTIVE SUBSTANCES

Through the generosity of Dr. Boris Pregel, an award of $500 is offered for the most acceptable paper embodying the results of research in the field of natural radioactive substances received during the year 1958. Announcement of this award will be made at the Annual Meeting of the Academy in December 1958.

IV. THE D. B. STEINMAN AWARD FOR RESEARCH IN STRUCTURAL ENGINEERING

Through the generosity of Dr. D. B. Steinman, an award of $500 is offered for the most acceptable original paper submitted from the Membership of the Academy in the field of pure or applied research in structural engineering, or in the related science of aerodynamics, or as applied to the analysis and design of civil engineering structures. The purpose is to encourage research, development, and writing in the subject of engineering sciences. This award will be announced at the Annual Meeting of the Academy in December 1958.

V. THE CONSUMERS UNION AWARD IN CONSUMER RESEARCH

Through the generosity of Consumers Union, an award of $1,000 is offered for the most acceptable paper on the subject "Science and the Consumer" submitted from the membership of the Academy. Consumers Union offers this award with the purpose of focusing on the practical applications of science to the needs of the consumer or on the concepts of science in terms of the consumer interest. This award will be announced at the Annual Meeting of the Academy in December 1958.

CONDITIONS GOVERNING THESE AWARDS

(1) *Eligibility.* Authors and co-authors applying for awards I, II, IV, and V shall be members in good standing of The New York Academy of Sciences or one its Affiliated Societies, but nonmembers may become eligible by joining one of these organizations before the closing date.

All scientists engaged in research in the field of natural radioactive substances may make application for award III.

(2) *Date.* Papers are to be submitted on or before October 15, 1958 to the Executive Director of The New York Academy of Sciences, 2 East Sixty-third Street, New York 21, N. Y.

(3) *Papers.* All papers submitted must embody the results of original research not previously published. The manuscript shall be typewritten, double spaced on bond paper, in English, and accompanied by all necessary photographs, drawings, diagrams, and tables, and shall be ready for publication. Papers must be accompanied by a summary of the data presented and conclusions reached.

(4) *Awards.* The awards shall be made by the Council of The New York Academy of Sciences, and its decision shall be final.

(5) *Publication.* The Academy shall have first option on the publication of all papers submitted unless other special arrangements have been made beforehand with the authors, but such publication is not binding on the Academy.

(6) Wherever and whenever published, the papers receiving the awards shall be accompanied by one of the five following statements:

Under award I, "Accorded an A. Cressy Morrison Award in Natural Science in 1958 by The New York Academy of Sciences";

Under award II, "Accorded a George Frederick Kunz Award in Geology and Mineralogy in 1958 by the New York Academy of Sciences";

Under award III, "Accorded a Boris Pregel Award for Research on Natural Radioactive Substances in 1958 by The New York Academy of Sciences";

Under award IV, "Accorded a D. B. Steinman Award for Research in Structural Engineering in 1958 by The New York Academy of Sciences."

Under award V, "Accorded a Consumers Union Award in Consumer Research in 1958 by The New York Academy of Sciences."

Such a statement, in substance, must also accompany any formal publicity initiated by the author regarding the award paper. If published elsewhere with the consent of The New York Academy of Sciences, six copies of each award paper must be deposited shortly after publication with the office of The New York Academy of Sciences.

THE NEW YORK ACADEMY OF SCIENCES
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Eunice Thomas Miner
Executive Director

PROGRAM OF THE EVENING

After the Business Meeting the following program was given:

DUTCHMAN'S BACCY JUICE OR GROWTH-PROMOTING AND GROWTH-INHIBITING SUBSTANCES OF MARINE ORIGIN*

By Ross F. Nigrelli

Retiring President, The New York Academy of Sciences, New York, N. Y.
and
Laboratory of Marine Biochemistry and Ecology,
New York Zoological Society, New York, N. Y.

The oceans and seas make up 70.8 per cent of the earth, or about 139,000,000 square miles. The volume of the earth is estimated at about 330,000,000 cubic miles.[1] The immensity of this mass will become readily apparent if we examine it in the light of something we can understand. Visualize, if you will, a box 0.5 × 0.5 × 0.4 miles or a volume of one tenth of a cubic mile. Such a container could easily hold the entire world population,[2] now estimated at more than 2,700,000,000 people – a little crowded perhaps, but probably no more uncomfortable than the subways during the rush hours!

These figures are well known. What is generally not known is that, acre for acre, the sea is more productive than the land. It is estimated that the sea yields from one to three tons of dry organic matter per acre per year.[3] There are some polemics involved here that we need not consider at this time; one investigator[4] estimates the total annual production of the oceans at 40 billion tons of organic matter, which is about the same as the annual production of plant life on land; another investi-

*A paper entitled "The Ocean Life of Pacific Salmons" was presented at the Annual Dinner and Meeting of the Academy on December 5, 1957 by Lionel A. Walford, United States Department of the Interior, Fish and Wildlife Service, Washington, D. C. This paper will appear in a later edition of the *Transactions*.

gator places the annual production of all organic matter in the sea at 150 billion tons of organic matter.[5]

The chief producers of organic matter in the oceans are the microscopic phytoplankton; seaweeds and other attached inshore plants play a minor role. Primary production, that is, plant growth, is estimated from the amount of carbon that is found in plant protoplasm. This can be measured in one of several ways, for example: (1) by the amount and rate of uptake of carbon-14 during photosynthesis;[4] (2) by the amount of nutrient depletion and oxygen released during photosynthesis in light and dark bottle experiments;[6] and (3) by measuring the size of the standing crop of plankton.[7]

The essential nutrients for plant growth are phosphates and nitrates. As will be seen later, these are not necessarily the only limiting factors (Liebig's Law of the Minimum) in phytoplankton growth. Most of these nutrients occur in the lower zones of the oceans. However, since green growth can take place only in the upper or euphotic zone, the way the bottom nutrients are made available for plant growth on the surface is of great interest to oceanographers and marine biologists.[1,8] In general, the nutrients are mixed and distributed by movements in the sea. Such movements are caused by prevailing winds, Archimedean forces, and by the spin of the earth. The maximal growth periods occur in the spring and autumn when the forces of the equinoctial gales continually mix the lower and upper layers of water. The nitrates and phosphates are released from the bodies of dead organisms by bacterial action, and some addition to the total supply of these minerals is also made by the excretions and secretions of animals.

It should be indicated here that the sequence of events of the nutrient cycle applies mainly to the eulittoral zone, that is, up to about 50 meters deep. The total turnover of the ocean takes place very slowly; complete top-to-bottom exchange takes from 150 to 1000 years.[2]

As in soils, the productivity of various regions of the sea differs, not only in quantity, but also in quality. It is these differences that have challenged the interest and imagination of marine scientists. Thus, it is said that "blue is the desert color of the sea." It is also generally known that there are large areas where primary plant production often fails to attain the potential maximum growth despite the presence of rich nutrients. Some, but not all, of these failures may be due to a combination of turbulence and low transparency and differences in salinities, temperatures, and currents.[1,9]

With time all things become relative. The early oceanographers were impressed with the fact that the concentrations of nutrient salts are remarkably small and that, for example, 1 mg. of phosphorus to a liter of water is sufficient to produce a vigorous growth of diatoms. However, many diatoms are now known to require vitamin B_{12} and other organic nutrients.[10-14] Theoretically, it is probable that the addition of one

millionth of a gram per liter of this essential growth factor would have increased the number of cells from one half to two times the number.

Recognition that organic nutrients may play an important role in productivity of the oceans has stimulated research along these lines. For example, Harvey[15] found that water collected near Plymouth, England, sometimes failed to support growth of diatoms. From experimental studies he concluded that the missing substances were complexes, which he called A and N. The biological effects of A substances on diatoms could be duplicated by adding L-cysteine, glutathione, methionine, vitamin B_1, or biotin. There is probably some significance in the fact that all these compounds contain sulfur. Water rich in A substances became infertile on standing and would not support growth until fresh A substances were added. The effects of N substances could be duplicated in part by the addition of certain compounds, among them alanine, lactic acid, dextrose, and gluconic acid, all of which form complexes with iron and manganese. Diatoms will grow in sea water enriched with nitrate, phosphate, and iron without accessory substances, provided that a small amount of manganese is present; they will grow better if silicon and trace elements are also present, but still better when accessory substances are further added.

It is now a proved fact that phytoplankton, or the primary plant producers of the oceans, are more exacting in their nutritional requirements, and rarely flourish in sea water enriched solely with phosphate, nitrate, iron, and manganese. Diatoms, which form the major group of phytoplankton in the sea, cannot now be considered strict autotrophs, that is, organisms that demand a purely inorganic type of nutrition.

Although this fact was recognized early,[16] it was not until recent years that it was placed on a firmer basis as the result of nutritional studies on a large variety of marine phytoplankton in pure culture. Thus, it is well known that so-called exacting species of phytoplankton will develop as persistent culture in *Erdschreiber*, which is natural sea water enriched with nitrate and phosphate and to which a hot water extract of soil is added.[17] This soil extract provides iron, manganese, a small quantity of silicate, and an array of biologically active organic compounds including thiamin, niacin, biotin, the cobalt-containing vitamin B_{12}, and several amino acids.

The inability to synthesize B_{12} (cyanocobalamin) or to synthesize it quickly enough for rapid growth is characteristic of many phytoplankton species. A supply of B_{12} in the water has been found essential for the growth of a number of algal flagellates in bacteria-free cultures; other species require thiamin in addition to B_{12} or, at least, the pyrimidine or thiazole portions of thiamin; still others also require biotin and one or more amino acids.[13, 18, 19] By the use of a variety of sensitive organisms for bioassay, certain marine waters have been found to contain as much as 10 gammas of B_{12} per liter of water.[10-12, 20-22]

Euglena, one of the organisms used for assaying this vitamin, is so sensitive that it will respond by increased growth in the presence of one part in a trillion (one micromicrogram, or 10^{-12}gm.) and by extending the time of the test, the sensitivity can be increased to one part in a quadrillion (1×10^{-15} gm.). This is far beyond the sensitivity of chemical and physical analysis. *Euglena* also responds to various forms of pseudo-B_{12} as well as to true B_{12}. Hutner[18] and his collaborators at the Haskins Laboratories, New York, N.Y., visualize the use of various phytoflagellates as assay organisms for these and other vitamins, specific amino acids, and other growth factors. By a systematic analysis they believe that it is possible to profile the growth-factor gradients of various regions of the oceans. This may prove useful to fisheries in predicting the potentialities of productivity of our coastal waters.

It is recognized by marine scientists that oceans contain more unorganized organic materials than living entities.[5] The bulk of the material is present in the sea in a suspended (leptopelic) and adsorbed (pelogloeal) state. Only a small fractional part per million occurs as true organic solute. It is this dissolved material, however, that attracts the interest of marine biologists and biochemists. It is such material that probably contains the growth-accelerating and growth-inhibiting factors.

What are the potential sources of such chemicals? Some of them represent bacterial decomposition or bacterial synthesis, while others are derived from secretions and excretions of plants and animals. Much has been written about the activities of bacteria and molds in the marine environment,[23] particularly in relation to decomposition and to the cycle of elements. However, very few studies have been made on these organisms, referred to as nannoplankton and ultraplankton by marine biologists, regarding their possible role in the production of specific substances that may become part of the pool of dissolved organics in the ocean. There cannot be any doubt that these organisms, with their great adaptive powers to varied metabolic processes, produce regulatory substances other than antibiotics and vitamins. The fact that the dissolved organics in the sea are not returned to the elemental state by bacteria may be related to the fact that the organic solutes are present in extremely dilute amounts and therefore are not available in sufficient concentration as substrate for enzyme action.

The role of external metabolites, that is, excretions and secretions of organisms, in biological phenomena has attracted the interest of biologists for many years. Space does not permit an adequate review of the many instances in which the activities of animals are modified by the presence of specific metabolic products within the immediate external environments. Without citing specific references, since the information may be found in any modern text on ecology,[24] I call your attention to some biological activities that may be influenced by external metabolites. The mechanism in these instances may be chemotaxis: (1) the mating

behavior of Protozoa and algal flagellates; (2) sex determination in aquatic organisms (for example, in *Bonellia*, an aberrant annelid, the sexually indifferent larvae receive some substance from the female proboscis that retards their growth and induces maleness; the males eventually live in polyandric relation as parasites in the nephridium of the female); (3) the swarming and spawning of many marine invertebrates; (4) the migration of fish to breeding grounds;[25] and (5) the attraction of sperm to eggs in fertilization (for example, F. R. Lillie's fertilizin, or the gamones of Hartmann; "Echinochrome A" or Gynogamone I, a bluish-red pigment of certain sea-urchin eggs, will attract sperm and activate motility in the tremendous dilution of 1 part in 2,500,000,000 parts of water).[26] A recent report showed that even the hatching and liberation of young barnacles is due to a water-soluble principle produced by the mantle and body-wall tissues of the parent.[27]

The idea that aquatic animals can affect the chemical characteristics of the water surrounding them was first explored in detail by the United States ecologist W. C. Allee,[24] who showed that aggregations of organisms conditioned the water by adding secretions and excretions. The chemical conditioning of the environment by a single species is called homotypic conditioning; it is called heterotypic when the effect is produced by two or more species. These substances, elaborated into the environment, may be either growth promoting or growth inhibiting.

An example of a favorable effect is demonstrated by the conditioning of water by goldfish. Allee and his collaborators, by carefully designed experiments, showed that the water conditioned by populations of goldfish is capable of increasing the growth rate of this species. Small goldfish are added to synthetically prepared "pond" water to produce a certain "conditioning coefficient." This coefficient is obtained by multiplying the number of fish by their mean length in millimeters and then dividing by the number of liters of water in the container. The fish condition the water by liberating organic matter and carbon dioxide.

Without going into details of the procedures that were followed in these experiments, Allee found that the fish placed in conditioned water grew more rapidly than those in clean unconditioned water. He concluded that the suspended food particles, the result of regurgitation of the conditioning fish, accounted for 80 per cent of the increased growth in the assay fish. When such particles were removed by filtration, the growth-promoting power of the conditioned water was decreased, but not completely lost. Also, there was a significant increase in growth even when the water was conditioned by starved fish. In a series of experiments, Allee and his students eliminated the possibilities that the increased growth might have been caused by changes in the total salt contents of the water, differences in *p*H and oxygen, or changes in the chemical elements. All this suggested that some growth factor other than food uptake must be present in conditioned water to account for the total ob-

served effect. Such a growth factor was found in the mucus of the fish, chemical extracts of which were found effective as growth stimulant in dilutions of 1:400,000 or even in 1:800,000. At these dilutions, it is not probable that the factor or factors in the mucus affect growth by furnishing food materials.[28]

The microbiologists among us will recognize the striking similarities between the phenomenon of conditioning by goldfish and the "allelocatalytic phenomenon" first described for certain Protozoa;[29] both are concerned with the favorable conditioning of the environment by its population through the elaboration of a growth-promoting substance. The allelocatalytic phenomenon is a highly controversial concept, and we need not discuss it here. However, the following observation merits some attention. It has been shown that a medium conditioned by a population of *Tetrahymena geleii* (holotrich ciliate) for at least 60 hours has both accelerating and inhibiting properties for growth. The medium from which the ciliates were removed by centrifugation was found to be capable of accelerating the growth of a fresh culture of *Tetrahymena;* the medium from which the ciliates were removed by filtration with Seitz or Berkefeld filters, on the other hand, was found to be inhibitory.[30]

The presence of various products of metabolism dissolved in the water may also help to explain the phenomenon of succession of organisms. In other words, what makes one species give way to another in the same environment, presumably under the same conditions? For phytoplankton succession, Provasoli and Pintner[19] of the Haskins Laboratories give the following interpretation: organisms affect one another (1) by interchanging growth factors; (2) by lowering inhibitory concentrations of several major mineral nutrients, especially phosphates; and (3) by preferential use, the concentrations of minerals and trace elements being brought to optimal levels that favor the growth of other forms.

We must not assume that the effects produced are always beneficial to the biota as a whole. Water conditioning has considerable practical importance in aquarium management, and even the fish hobbyist is well aware of this phenomenon. However, the hobbyist also knows that water conditioned by one species of fish may be toxic to another species. The products for this deleterious effect may be derived from the mucoproteins in the skin glands or from nitrogenous metabolic wastes.

The successions of organisms within an ecological niche would indicate that antibiosis is a widespread condition and not necessarily limited to microorganisms. In a marine environment, a diversity of processes may be anticipated. Antibiosis may occur among fishes, among invertebrates, between phytoplankton and zooplankton, between algae and bacteria, and *ad infinitum*.[31-35] For example, a rich phytoplankton growth does not always mean that the region will support a large and varied population of fish and other animals. Thus, some of us are familiar with the catastrophic effects of a condition called the "red tide," a discoloration

usually caused by dinoflagellates, a species of phytoplankton. This condition in the sea appears sporadically and has been known for a long time; Charles Darwin was one of the first to report observations of the phenomenon, off the coast of Chile, after his voyage on H.M.S. *Beagle*. In our own time, the red tide off the Gulf coast of Florida in 1946 and 1947 was one of the most severe ever recorded.[36] This outbreak was caused by the dinoflagellate *Gymnodinium brevis*, colloquially referred to as Jim Brevis. At the height of the outbreak, all the beaches from Fort Myers north to Tarpon Springs, Fla., were littered with bodies of dead fish that had accumulated at the rate of more than 100 lb. per linear foot.[37] It is conservatively estimated that more than 50 million fish died. When I visited the area in the fall of 1946 at the invitation of Pinellas County officials, the beaches were covered, not only with dead fish, but also with numerous defunct crabs and other invertebrates; even pelicans and porpoises were reported dead.

It is my opinion that the mass mortality can be explained only by a typical chain reaction. The first fish to die or become moribund were the plankton feeders; the weakened fish became prey to predators, and these in turn were poisoned and attacked by other fish. In a relatively short period the waters in the area of the red tide teemed with dead and dying fish. Some areas, especially the waters close to shore, became so toxic that eels, crabs, and other bottom animals struggled to get out of the poisonous water by beaching themselves. Eventually the dead fish were washed ashore and, under the action of the hot Florida sun, a "stinking mess" was created, resulting in a serious public health situation. The air was filled with a toxic substance that caused severe irritation of the eyes, nose, throat, and lungs. Whether or not the volatilized irritant and the toxic material of the dinoflagellates were one and the same was never firmly established. Preliminary analysis of the red tide poison indicated that the agent may have been an alkaloid compound related to trimethylamine oxide, probably one of the pyridine derivatives. The toxicity of the entire environment, both in and out of water, may have been due to the presence of trimethylamine oxide, glycine betaine, and gamma-butyrobetaine, since these alkaloids are present in marine teleosts, crustaceans, squids and other mollusks and coelenterates,[38] all of which were involved in the red tide mortalities.

The factors responsible for the bloom have been considered carefully. If we recall the role of the *Erdschreiber*, that is, the growth-promoting effects of soil extracts on phytoplankton, one of the factors responsible for the outburst will become apparent. Without going into details of the hydrographic and other oceanographic influences,[39] it is sufficient to indicate that the bloom and its recurrence are related to the extensive drainage program on the west coast of Florida. Here we have a runoff of water rich in phosphates and organic nutrients, such as may be found in

soil extract; under optimal physical, chemical, and biological conditions this runoff can result in the tremendous growth of the dinoflagellates.

A more subtle example of the effect of rich phytoplankton growth on fish is shown by the following example. English fishermen know from experience that a net will not trap herring if it is coated with a brown growth. The skipper refers to this as Dutchman's baccy juice. The slimy condition and discoloration is caused by large numbers of diatoms, a species of brown algae.[8,40] Study of the factors involved led the great English planktologist, Alister Hardy,[40] to propose a theory of animal exclusion. There are intricate ecologic relations between zooplankton and phytoplankton in this phenomenon, but not enough space has been allotted to discuss the biological factors involved. Metabolic products of the diatoms are suspected of being responsible for this exclusion effect.

A more complicated interrelationship is indicated by the low and high productivity of certain water masses in the North Atlantic when two species of arrow worms, *Sagitta setosa* and *Sagitta elegans*, are present. Water with large populations of *setosa* is invariably poor in other organisms including fish, whereas water in which *elegans* predominates is often rich in phytoplankton, zooplankton, and in fish.[37,41] The differences in these waters can be explained only by the presence of factors other than just physical and hydrographical features.[42] Thus, it has been experimentally demonstrated that eggs and larvae of sea urchins and certain marine annelids showed a higher degree of abnormal development and low viability when hatched and reared in *setosa* water (as in the English Channel) than in *elegans* water (as in the Celtic Sea and Firth of Clyde).[43-44]

The lethal aspects of organics in sea water, or the presence of toxic metabolites released by phytoplankton and zooplankton, may have some important bearing on the problems of dynamics of fisheries. For example, these substances may prove to be the factors responsible for the *M* effect in fluctuations of fish populations. *M* is a measure of the fatally adverse effects of the environment upon a population of fish, usually attributed to physical and hydrological factors.[45] It stands for the rate of natural mortality, that is, mortality from causes other than fishing. No method has been devised for measuring this *M* effect and, for this reason, it is treated as a constant. However, natural mortality is not a constant, since it is well known that mass mortalities may occur as a result of phytoplankton bloom, sudden temperature changes, and other abnormal conditions. Furthermore, it is also well known that epizootics and other insidious infections or infestations may also take heavy tolls of fish populations. It is also probable that the metabolites of certain plankton may produce subtle effects on fish larvae that form part of every plankton population. Under normal conditions the larvae of many species may be able to withstand a low level of toxicity (ecologic adaptation), but this

level may become lethal if and when the resistance of the fish is altered by oceanographic and other factors.

It should be reiterated here that the biologically active compounds, dissolved or in colloidal suspension, are present in very dilute concentrations in the sea. Some special filtration and extraction methods have been developed for collecting and analyzing these materials.[46-48] Recently Johnston,[48] working in the Plymouth laboratory in England, attempted to analyze the biochemical characteristic of natural sea water, especially the *Sagitta*-"labeled" waters. Several organic fractions were obtained and these were characterized chemically, but not specifically defined. However, when bioassayed on several species of diatoms and phytoflagellates, the fractions were found either to favor or to inhibit growth.

A number of specific organic substances have been extracted from dissolved and suspended materials in the sea. These have been identified as carotenoids and sterols,[5,46,49,50a,b] vitamin B_{12},[10-12, 20-22] ascorbic acid, rhamnose[51] and other polysaccharides,[51-53] tyrosine, and tryptophan.[52] Even free enzymes were extracted from sea water, some of which were found to be capable of metabolizing ammonia and nitrate.[54-55]

It has been indicated[52] that these compounds may produce their effects on the biota as regulators or stimulators of feeding activities and other movements of marine animals. It has also been suggested that the dissolved organic substances in the sea are used by zooplankton, including fish, for energy and protein synthesis. This idea has some support from numerous experiments in which the activity of biologics in solution (for example, hormones, vitamins, and antimetabolites) are assayed on fish and other aquatic organisms.[56]

The utilization of dissolved organic compounds by zooplankton is expressed in Pütter's hypothesis[57] that postulates that zooplankton derives much of its nutrition from such substances in water. This controversial hypothesis is still stimulating research[52,58] and, as the techniques are refined, it will doubtless be found that holozoic forms may be maintained in a nutritionally defined liquid medium. It is well known that certain holozoic ciliates (for example, *Tetrahymena*) can be and are maintained in a defined organic medium containing no particulate food. At present the balance of evidence is in favor of the theory that some utilization is made of dissolved minerals in the nutrition of zooplankton, although the possibility that dissolved organic substances are used cannot be entirely eliminated.[59] Pütter's hypothesis must be re-examined in the light of our present knowledge of the nutrition of holozoic forms. Some of the objections to this hypothesis raised by certain physiologists[60] may be eliminated by studies on axenic cultures of metazoan animals now in progress.

C. E. Lucas, of the Scottish Fishery Laboratory at Aberdeen, Scotland,[61-62] has stressed the idea of interaction between organisms and the

possible significance of the various substances released into the water by plants and animals as the result of their physiological activities. He believes that the metabolites are beneficial or antagonistic. In extreme instances such nonpredatory relationships result in escape, exclusion, or death on the one hand and obligatory association (parasitism and symbiosis) on the other. Lucas further states that such processes are important in evolution and that they mediate communal relationships in ecology, which is the temporary aspect of evolution. In any event, the products of metabolism must be considered as part of the ecologic complex, which includes the physical and chemical relationships, as well as prey and predator.

It is not the purpose of this presentation to list all the biologically and therapeutically active agents that have been extracted from marine organisms. The literature in this field and the commercial use of marine products have been reviewed in recent years in a number of books and monographs.[31,63-66] For those interested in comparative biochemistry, I call attention to a few of the more interesting compounds that have been isolated from the tissues and body fluids of fish and of many invertebrates: (1) ergosterol and dihydro-ergosterol from the marine annelid *Arenicola;* (2) morrhuic acid from the liver of the cod, the sodium and copper salts of which have been found effective as a reticuloendothelial stimulant and as a sclerosing agent; (3) murexine or urocanyl-choline from the hypobranchial glands of the mollusk *Murex* that has strong nicotinic and curariform actions;[67] (4) 5-hydroxytryptamine (serotonin), a potent histamine releaser from certain coelenterates and mollusks;[68-69] (5) tetramethylammonium chloride and related quaternary ammonium compounds from sea anemones and numerous other invertebrates (it is this substance that is responsible for the "sting" of certain jellyfish); (6) nicotinic-methylbetaine (trignonelline), a common plant alkaloid from sea urchins and jellyfish;[38] (7) amine oxidase from *Sepia,* which is active in the oxidative deamination of tyramine; (8) sulfatases from numerous snails, especially periwinkles; and (9) thiaminase from herring, smelts, and clams.[70]

In addition to these agents, basic compounds that have been identified as derivatives from marine animals and algae are sterols and lipids,[71] carotenoids,[72] porphyrins,[73] pterins, peptides, nucleosides,[74] nucleotides, amino acids,[75-76] glycoproteins, polysaccharides,[31] vitamins, and antibiotics.[32-33] Recently, even cholesterol has been extracted from red algae.[77]

Some of these products and their derivatives have been found useful as anticoagulants, plasma substitutes, cardiac stimulants, and other therapeutic agents. Of special interest are the numerous toxic compounds that are known to occur in marine organisms.[78-79] Their potential use as therapeutics has been suggested by many investigators.[80]

It was a similar idea that led us to extend our studies on the ecologic significance of a toxic metabolite released into the water by the Bahamian sea cucumber *Actinopyga agassizi*. This substance, which we have called holothurin,[81] is stored in the Cuvierian organs and liberated just prior to or during evisceration, a phenomenon of autotomy or self-mutilation; presumably a survival mechanism. Fish that come in contact with this secretion die within a few minutes, even at a dilution of 1:1 million or more. Once the fish is exposed to a lethal concentration there is no recovery. Analysis of holothurin showed that it is highly water soluble, nonvolatile, and heat stable. Our initial guess that it was a steroid saponin was later substantiated by preliminary chemical analysis.[82] Toxicological and pharmacological tests indicated that holothurin is highly toxic to a variety of organisms[83-85] and that it has strong hemolytic properties.[86] This compound also has some antitumorous activity, especially on Sarcoma-180 and Krebs-2 ascites tumors in Swiss mice.[87-88] It is further indicated that only a small fraction of the holothurin complex is active in this respect. Detailed studies, in collaboration with biochemists working under the direction of Harry Sobotka, Mt. Sinai Hospital, New York, N.Y., are now being made to unravel the chemical structure of this very interesting digitalislike glycoside. The sugar constituents of holothurin have been identified as glucose, xylose, and D-fucose. The presence of the D-form of fucose in animal material is rather unexpected. The L-form of this methyl pentose is widely distributed in nature; for example, it is found in human blood groups substances, in antibodies, in virus hemoglutination-inhibitory mucoproteins, in influenza virus, and in some pathogenic organisms. Large amounts are present in the polysaccharides of brown algae (*Fucus*), in green algae, and in the jelly coat of several species of sea urchin eggs.

With the development of sensitive bioassay and biochemical methods, the time is now ripe for extensive investigation in the field of marine biochemistry. Most of the present knowledge in biochemistry has been gained through studies on about one dozen animal species, all of them land forms. The animal kingdom is composed of about 12 phyla (modern taxonomists have increased this number to 32) and the majority of forms (more than 500,000 species) live in an aquatic environment, or at least spend part of their life in this milieu. If the intensity of research in marine biochemistry is greatly increased, we can safely predict that it will be necessary to rewrite all the known chapters of plant and animal chemistry and that many new chapters will undoubtedly be added.

The biochemical aspects of marine biology have long been neglected, and it is now apparent that such studies are essential if we are to understand the complete story of productivity in the oceans. With the population of the world increasing at the annual rate of 44 million, the time is fast approaching when we must take careful stock of our last great

natural resources[89] and make certain that they are not exploited indiscriminately, despite the fact that some marine biologists[90] believe that this will not be possible.

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SECTION OF BIOLOGY AND DIVISION OF MYCOLOGY

I. FOOD, SCIENCE, AND PEOPLE*

By J. G. Harrar

The Rockefeller Foundation, New York, N. Y.

Introduction

The growing body of literature on the balance between world population and food supplies reflects the increasing pressure that mankind is placing upon science and technology with each succeeding generation. A study of this material reveals that individuals representing a wide variety of disciplines in the physical, chemical, biological, and social sciences, as well as those interested in the humanities, are becoming acutely aware of the implications of explosive increases in population with which the world is presently faced. When it is realized that mankind has increased from approximately 500 million in 1700 to 1.25 billion in 1900 and 2.5 billion in 1950, the demographic problem resulting from pure increases in numbers becomes startlingly apparent. Extrapolated into the future, the problem becomes frightening. At some stage society will find it necessary to cast up the balances between expanding human requirements and the capacity of the world to satisfy them in the immediate and more distant future. The remarks that follow represent an attempt to examine certain aspects of the population and food problem and raise questions that must be resolved by society as a whole if mankind is to attain adequate standards of living and human dignity during at least the next century.

The scholars concerned with the balance between procreation and production tend to divide themselves generally into two categories. One group seems convinced that man's mismanagement of the world's natural resources, coupled with the uncontrolled increase in human population, essentially guarantees ultimate chaos through the sheer weight of numbers. The other school of thought holds that, with adequate economic support, human imagination and ingenuity will enable science and technology to improve in all of their aspects and to break through some of the existing barriers to greatly increased production. Presumably this would result in enormous gains in available energy and an agricultural and industrial productivity so much greater than is presently possible that current

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estimates would be nullified. This group believes that these developments will occur within the foreseeable future and that the world can then comfortably accommodate two and three times its present population, and perhaps even more.

Obviously, there are many variations on these two themes, and it would be inaccurate to suggest that all observers or students subscribe fully to one or the other philosophy. It is my personal belief that there are basic truths in each point of view that in themselves tend to modify each conclusion. I should say, however, that in spite of my deep faith in the capacity of all fields of science to combine to achieve technological heights as yet not envisioned, I am definitely perturbed by my growing conviction that science and technology could lose the battle to unlimited procreation. I believe that, unless there is a determined and organized effort on the part of all sectors of society to balance population increases with social and scientific advances, grave problems lie ahead. The question is not just one concerned with sufficient food for millions and even billions of additional hungry mouths, but rather one involving, in addition to an adequate dietary standard, opportunities for education and employment and the development of social standards of living compatible with human dignity. There is perhaps too great a tendency to seek an arithmetic solution to human problems whereas, in truth, the total answer can be given only in humanistic terms. The sections that follow attempt to delineate certain current and future problems, suggest ways in which science may contribute to their solution, and indicate the necessity for comparable social adjustment.

Present World Food Supplies

The most sobering fact encountered in the study of ways and means to feed future generations is that the world of today is completely unsuccessful in providing satisfactory diets and standards of living for even one half of its citizens. We are thus forced to discuss possibilities of future success in providing for billions more people than are now in existence, although our past record has been one of substantial failure. As currently estimated, the world's population approximates 2.6 billion. In support of this number of individuals world food production is in excess of 900 million tons annually. This quantity is totally inadequate to provide the ideal of approximately 3000 calories per capita. In fact, it supplies only 25 per cent of the population with more than 2750 calories daily, 20 per cent with 2250 to 2750, and 55 per cent with less than 2200 calories daily. Since two thirds of the world's labor force is engaged in agricultural pursuits, these figures emphasize the fact that a disproportionate fraction of the population of the earth is chained to inefficient agricultural practices with comparable losses to industry, business, education, and the arts.

Obviously production capacity in terms of human effort varies enormously throughout the world. Individual human output is critically affected by health, education, and economic resources. In certain areas favored by geography, human and natural resources have been combined to develop the highest standards of living that thus far have been obtained and have produced agricultural surpluses that are piling up at an alarming rate. In contrast are those less favored regions with natural barriers to efficient crop production, public health problems, inadequate natural resources, and restricted educational opportunities. In these areas yields of domestic crop plants and animals are among the lowest in the world, labor requirements are excessive, and standards of living are inadequate. For example, completely mechanized rice culture in the best areas in the United States requires two to four man-days to produce rice at the rate of 3500 lb. per acre, whereas in certain of the more primitive rice-growing areas in the world 400 man-days of labor are necessary to produce 700 lb. or less of rice per acre. In terms of calories the United States, with 6 per cent of the world's population, produces 15 per cent of the total world food supplies and has an average per capita caloric intake of 3100 calories daily. India, with more than twice the population of the United States, produces only about 7 per cent of the world's food supply and has an average caloric intake of 1640 per capita daily. Moreover, the United States uses only 8 to 9 per cent of its total labor force in achieving its current position of overproduction with respect to agricultural commodities, whereas India underproduces local demands even though utilizing 70 per cent of its labor force for agriculture.

Many reasons are given for these extremes in agricultural efficiency. These are frequently colored by the particular interest or philosophy of the individual concerned, but together they add up to a formidable series of problems that require solution before the world can hope to rectify current inequalities, not to mention provision for increased future demands. Among the more important barriers to efficient agricultural production the following may be cited as critical:

Soil. Man is his own greatest enemy in the matter of contributing to the destruction of arable soils that has now reached the point at which millions upon millions of acres have been partially or totally ruined for agricultural purposes. As the most optimistic estimates indicate that the world can never expect to have more than approximately four billion acres in crop production, the prevention or control of erosion quickly becomes of critical consideration. Opinions vary as to whether badly eroded areas can ever be restored to productivity, but with time and intelligent management, some could be brought back to a level of productivity at which they could contribute to needed food supplies. Unfortunately, time is the least available commodity, and only when pressures become irresistible do political and economic measures come into play, and then only very slowly. Meanwhile, urbanization, industry, flood con-

trol, and other public works continue to encroach upon valuable agricultural soils, with the result that possibilities for increasing food supplies by bringing new land into production are now essentially being nullified by the rate at which land is being taken out of agriculture.

Much of the world's land surface is barred to the practice of agriculture by climate, as in the Arctic and, to a degree, the sub-Arctic regions. Also, while the humid tropics represent our greatest potential resource in terms of solar energy and humidity, many tropical soils are low in productivity. Moreover, heavy economic investments are required to make life in the tropics attractive to entrepreneurs who might successfully develop local agricultural potentials. The tropics of Africa, Asia, and much of South America have thus far failed to contribute their share to world food supplies, and they represent the greatest remaining land resources that could be brought under cultivation in response to human need. Here again, however, the time factor is critical; there are many obstacles to rapid progress so that it cannot be expected that this resource will become fully developed in the early future.

Water. Water is all too often the limiting factor in crop production. Modern agriculture demands that man manipulate domestic plants and animals for his benefit; in doing so, he must give first consideration to soil and water requirements. In certain instances water may be in excess, but unfortunately in the vast majority of cases inadequate water supplies constitute the major barrier to optimum yields. The conventional practice of putting crops in the ground at that time of the year when it is hoped that subsequent rainfall will be of sufficient quantity and distribution to support normal plant growth is risky. The conventional farmer is always at the mercy of the elements and can never be completely sure that during any given year he will have normal production rather than crop failure due to drought or other causes. Although there are many reasons for crop failure, the most important is lack of sufficient quantities of water during critical periods in the growth cycle of crop plants. Man has learned to compensate for the vagaries of nature through techniques of irrigation in those areas where natural bodies of water, artificial impoundments, or adequate subsoil pools are readily available. He has found that irrigation provides insurance against undesirable variations in rainfall patterns and offers the additional advantage of permitting the application of adequate quantities of water during the time when moisture is of greatest significance in supporting growth and reproduction. Many otherwise potentially productive areas are condemned to desert status because of the unavailability of water for agricultural purposes.

Pests and diseases. To add to the many other ills of agriculture, the world is populated by an amazing array of microorganisms that annually extort tolls of agricultural products sometimes reaching 15 per cent of gross production. Estimates vary, but there is little doubt that at least 100 million tons of food are destroyed each year through the activities of

insects, fungi, bacteria, viruses, nematodes, and weeds, which parasitize crop plants and domestic animals. In an effort to prevent this total from becoming very much greater, agriculturists are forced to make heavy investments in insecticides, fungicides, and herbicides, and the machinery for their application. These represent economic sanctions imposed upon agriculture by pests and diseases. In many areas, economic resources are inadequate to permit the regular application of protective compounds to prevent disease epidemics. The result may be heavy annual losses or forced change to cropping patterns that are less economic in terms of supply and demand.

Mineral resources. A major factor in the inequalities that exist in standards of living in various sectors of the world is the distribution of mineral resources. Deposits of base and precious metals, radioactive substances, nitrates, phosphates, sulfur, and potash are all critical in the rational development of agriculture. The successful utilization of mineral resources inevitably demands large quantities of cheap energy. These can be satisfied only where there are readily available sources of coal, petroleum, water power and, more recently, fissionable materials. Since power demands are increasing enormously each year it is quite evident that energy quickly will become the limiting factor to future agricultural and industrial production unless additional resources can be tapped or developed.

Human resources. As previously suggested, the human factor is of paramount importance in the problem of world food production and living standards. It is obvious that healthy, well-nourished individuals are most productive, and they of course require an adequate diet to support their output of energy. Of at least equal importance is the understanding and competence that can be applied to the art of agriculture by individual growers. Among the most serious barriers to the production of food crops and domestic animals are ignorance and tradition, which lead not only to low yields but to wasteful use of land and other resources, as well. To the unlettered citizens of many lands the benefits of modern agriculture are mysterious and out of reach; until education becomes an integral part of the experience of essentially every individual, there is little hope that science and technology can correct the present unsatisfactory ratio between numbers of individuals and human nutrition. It would seem, therefore, that society will have to invest vastly increased funds to make the benefits of education generally available and to utilize resultant improved manpower most effectively.

Role of Science in Food Production

Those who insist that adequate food supplies and comfortable levels of existence for all of the people are the responsibility of science and technology produce a wide variety of statistics to support their contention. They point out that the potential world food supply is limited only

by the capacity of the globe to produce carbon compounds. They cite the fact that total crop production on cultivated land alone approximates 4 billion tons, which in theory could support nearly 30 billion people. Actually, however, half of this amount is eaten by animals that convert only 3 to 5 per cent of the total into food for mankind. Of the other half that occurs in the form of crop plants, only about 20 per cent is currently usable as food. If, then, there were no losses to contend with, present agricultural production could be expected to support a maximum world population of 3.5 billion. However, storms, floods, pests, diseases, and waste reduce this total to the point where currently available world food supplies, even if properly distributed, could support only 2.3 billion people at recommended rates of caloric intake. This number is less than the actual population, and inequalities in purchasing power and the distribution of commodities result in extremes in agricultural surpluses and deficits and per capita caloric intake in various parts of the world.

The sea and noncultivated land together produce more than 150 billion tons annually of carbon compounds; if a relatively small percentage of this total could be economically transformed into food and feedstuffs, world food supplies would increase proportionately. Science is not defeated in this matter, and there are already dramatic demonstrations of the effects of the scientific method on average yields of crop plants and animal products. Yields of certain plant and animal products from the practice of agriculture have doubled, trebled, and even quadrupled during the past fifty years, and the more complete utilization of domestic animals and cultivated plants as food substances has contributed significantly to human nutrition. Nevertheless, all of these advances have resulted in average annual increases in food production that, according to most optimistic estimates, do not reach 2 per cent per year. At this rate the world level of human nutrition cannot gain on population and, with the addition of nearly 100,000 new citizens each day, production may well lag even further behind the need. If, however, society is willing to provide greater support to science and technology, there is little doubt that dramatic improvements can be made in the production and conversion of nonfood carbon compounds into forms that can be readily assimilated by man. These improvements alone will not in any sense resolve the critical problem of balance between food and people that lies ahead, but could be a major contribution toward its solution. Several specific possibilities are described in the following paragraphs.

Plant improvement. Of the approximately 300,000 plant species that have been described, less than 3000 have ever been used for food; only 300 are now widely grown, and a mere dozen provide the world with over 90 per cent of its annual food supplies. Thus, there still exists a rich resource from which it is certainly reasonable to expect that plant species of great natural value in terms of ratio between consumable foods and by-products may be selected, domesticated, and brought into production on a wide scale. Plants already domesticated can be further im-

proved through conventional breeding techniques and nonconventional methods leading to the establishment of wide crosses that will blend the desired characteristics of two or more types that are not necessarily intimately related phylogenetically. The science of genetics is progressing with great rapidity and, as we understand more fully the function of the nucleus and cytoplasmic inclusions in relation to ontogeny and metabolism, we may be able to develop plant types several times more efficient as food producers than those conventional forms currently in use. Physical and chemical methods of modifying cellular behavior are already available and will doubtless be of major importance in making it possible to increase productivity further. Sooner or later we should be able to improve substantially the quantity and quality of food species harvested from the sea.

Soil improvement. Science is making tremendous progress in understanding the soil as a living medium upon which food and other plants depend for major quantities of water and mineral nutrients. We are learning to alter or modify the physical, chemical, and biological properties of the soil for improved production. Ecologists and agronomists have studied the roles of soil and climate in relation to crop production and have developed ingenious systems of combining applications of water and nutrient elements at critical times with predetermined cropping patterns for maximum production. The roles of micronutrients in crop production are becoming better understood, and modern soil management has resulted in increasing the carrying capacity of agricultural soils to levels once believed impossible. Where there are no soils we have learned how to create artificial hydroponic systems that are invaluable for special purposes; that is, the production of noncontaminated vegetables for military personnel abroad, high-quality cash crops for winter markets, and the production of vegetables in areas without arable soils where necessity makes this practice economically feasible.

Soil microbiology is a most complex science, but it has gradually begun to reveal some of its secrets to investigators. Progress is being made in learning to influence populations of soil microorganisms in order to increase the rate of decomposition of crop residues; to augment the quantities of available nitrogen and phosphorus in the soil; to change soil *p*H; and to create antibiotic barriers to soil-borne pests and pathogens. Doubtless as our understanding of the biology of soil types throughout the world improves, many modifications can be brought about with resultant benefit to economic crop production.

Protection. In the past we have depended principally upon exclusion and external treatment to protect domestic plants and animals against pests and parasites. Many quarantines have been effective in excluding insects and pathogens, and modern sprays, dusts, and slurries are of great value in the protection of seeds, plant parts, and animals from those pests and pathogens that would otherwise take a much heavier

annual toll of food production. Many of the great sweeping epidemics of plant and animal diseases that were long feared as regular occurrences have been gradually brought under control and in some instances essentially eliminated. Nevertheless, 15 per cent or more of the world's food supplies is destroyed each year by parasitic or pathogenic microorganisms.

Great strides are being made in plant and animal protection as the result of fundamental studies of hosts and parasites and their metabolic relationships. The conventional systems of plant protection are gradually giving way to new methods in which the use of synthetic systemic compounds, antibiotics, and naturally occurring protective substances may well provide greatly improved protection at a lower cost. In combination with the use of resistant varieties, mechanization, and modern management techniques, these methods offer increasing hope that we may more nearly close the gap between potential maximum production and the actual figures that reflect heavy economic losses from the attack of pests and pathogens.

Mechanization. The increasing use of modern machinery in those areas where such investments are possible has resulted in greater yields and lower costs for many of the major crops and domestic animals. Land preparation has become more rapid and more efficient and less costly. Planting, fertilizer placement, and cultivating are handled more simply and quickly than ever before, as are applications of herbicides, insecticides, and fungicides. Once a crop is mature, machines again assume control in the harvesting operation and continue to play important roles in such postharvest processes as packing, shipping, freezing, drying, and canning. With the help of modern devices, quality is maintained, spoilage is avoided, and losses in processing are minimized, with resultant benefits to human nutrition. With adequate supplies of raw materials and cheap power sources, the use of mechanical devices in agriculture would undoubtedly increase many fold and make dramatic new contributions to production. In the first instance this would reduce still further the number of individuals required in the practice of agriculture; in the second, fruits, vegetables, cereals and meat, and milk products of improved quality would be produced in significantly increasing quantities. Eventually much of animal husbandry may yield to techniques of the production line for greater efficiency.

Agricultural chemistry. Modern chemistry is making what are perhaps the most dramatic modern contributions to agriculture. The use of chemical fertilizers and protectants has already been mentioned and the traditional materials have now been joined by a host of new compounds that are gradually enabling man to dominate domesticated plants and animals more completely and precisely for his benefit. Through basic studies of plant and animal metabolism, chemical methods are being found that influence physiological processes to bring about a host of desired modifi-

cations in plant and animal behavior. Many modern plants are both visibly and invisibly different in structure and function from their ancestors. Through chemical and other techniques we have learned to produce dwarf varieties with improved ratios between waste and desired food products; to alter the growth habits of plants and animals so that larger quantities of desired food products are produced in shorter periods of time. We can induce or delay flowering, prevent fruit drop, delay senescence, modify disease resistance, and control numbers of offspring. Thus are we learning to tailor our plant and animal servants to our own requirements and by so doing make it possible to increase further the proportions of usable end products to waste materials. Moreover, many of the so-called waste materials of the past have now become economic assets through chemical transformations. Some transformations may result in nonfood industrial products, but others have contributed directly to world food supplies by changing relatively indigestible materials into substances that can be utilized as food or feedstuffs.

If there is to be any major breakthrough in the rate of annual production of food supplies, it will undoubtedly occur in part because of important developments in the fields of basic and applied biology and chemistry. Many substances are already in use and new possibilities for further improvements are becoming increasingly apparent every day. Examples are gibberellin, the antibiotics, hormones, synthesized organic compounds, and a wide range of as yet unidentified extracts from plant and animal organs. Each year there are new discoveries that help in the better understanding of cellular metabolism and suggest ways in which life processes can be further modified for the greater production of desired commodities. Biochemical studies of the nucleus and of cytoplasmic inclusions, enzyme systems, and the process of photosynthesis provide an accumulating body of data that may ultimately offer keys to methods by which plants and animals can be more precisely influenced and manipulated for the benefit of mankind. If it were possible to increase significantly the rate at which photosynthesis takes place; to increase the efficiency of water utilization in plant cells; to control growth rhythms more precisely; to induce symbiotic nitrogen fixation in cereal and other nonleguminous crops, or to control the balance between vegetable growth and fruit or seed production, the annual rate of increase in food production in the world might easily be 3, 4, or even 5 per cent instead of the present rate of less than 2 per cent.

In spite of man's long association with plants and animals and his absolute dependence upon them, we are still groping at the threshold of understanding with respect to their metabolic processes. If society is willing to provide very much greater support to the chemical as well as other approaches to basic biology, chemistry doubtless will return the investment many fold.

Energy. In any discussion of increased world food supplies and improved standards of living, energy must have a major role. Although reserves of conventional sources of energy, that is, petroleum and coal, have increased during the past fifty years, it is not clear that newly proved reserves will be found at similar rates in the years to come. In any event these resources are not inexhaustible, and it behooves us now to think about coal and petroleum in terms of what we shall do as our reserves begin to dwindle. Further developments in water power are still possible but these represent an insignificant fraction of total future power demands.

Solar energy presents a tantalizing subject for speculation because every day the world receives energy from the sun at a rate of approximately 2000 times the amount of energy that man presently contrives to use. Physical methods for the utilization of this energy are well known, but thus far they have been unable to compete to any significant degree with conventional sources of power. Solar cookers, space heaters, pumps, and engines have been developed experimentally and have had at least a limited utility under rather special circumstances. If and when free solar energy can be economically captured in vast quantities and used for the comfort and well-being of mankind, the resultant benefits will be enormous. Electrical and photochemical conversion processes for the transformation of solar energy into power have been investigated to some extent for many years and have now become the object of more intensive study in the hope that they will lead to economic supplements to present power resources.

Nuclear energy is a subject about which accurate long-range forecasting is difficult. However, rapid progress is being made in the technology and all the evidence suggests that the energy product of atomic fission will provide enormous power supplements to industry, agriculture, and urban development. Large reserves of uranium are available and, sooner or later, nuclear fuel stations will probably assume major importance as energy sources. Fission batteries and reactor heaters are also potentially important and, if it should become possible to master the fusion reaction on an economic basis, then power would become the least of our worries for an indefinite period in the future. Although nuclear fission has long been a subject of pure speculation, recent developments have stimulated scientists to the conviction that it can be mastered and ultimately harnessed for the benefit of society.

It is unrealistic to assume that because of need the energy question will be resolved promptly and effectively by science and technology. Certainly, one potential breakthrough has already occurred, that is, nuclear power development; others may occur that would put many presently unavailable resources at the service of society. With great quantities of relatively cheap power the conversion of sea water to fresh water for irrigation purposes might well become practicable, as

would the extraction of salts and minerals from sea water and the mass culture of useful microorganisms for use in agriculture and industry. The transformation of proteins from noncultivated plants into foods and foodstuff would be facilitated and a whole host of new possibilities for adding to world food supplies would become apparent.

Examination of past and present scientific progress and future possibilities rather clearly suggests that science and technology, under favorable circumstances, can make immense contributions to vitally needed food supplies for future generations. The possibilities are many and exciting; without doubt the accomplishments of the next several decades will be as dramatically superior to those of today as the latter are in comparison with those of the early 1900s. Important and encouraging as these expected developments may be, they do not ensure that population growth will not continue to outstrip their total capacity for production. It would seem axiomatic that ultimately the requirements of unrestricted population increases will exhaust man's ingenuity and the supplies of natural resources.

People

In the preceding sections I have attempted to outline what appear to me to be certain of the more important considerations involved in the role of science in meeting present and future demands for human food. To me these add up to the conclusion that society, as of the present moment, is unsuccessful in providing reasonable standards of living for all of its citizens and that there is no evidence that this situation will soon be rectified. While there is encouraging evidence that science can make significantly greater contributions to world food supplies during the years to come, it does not appear that conventional methods, even as they improve, can result in production levels that will balance to any reasonable degree the numbers of people who may be expected to populate the earth a hundred or more years hence. If dramatic new advances in science occur that permit power and production increases at different orders of magnitude than are presently possible, then immediate worries fade into the more distant future. However, it is unrealistic to assume that future technological progress will provide for any number of citizens that society cares to impose upon the already heavy burden of human nutrition.

In the last analysis the true standard of living of any country is that enjoyed – if this is the word – by the great majority of its citizens. Actual levels in a given area are the product of human potential times natural resources. When one factor is lacking to any significant degree, living standards necessarily suffer. There are areas in the world in which per capita income is relatively high because of some special resource, such as petroleum, but the standards of living of the masses are

pitifully low. Only when the benefits of education, training, and opportunity are extended to the bulk of the individuals populating a specified country can that nation expect to improve its economic position through the development of its own resources, both natural and human, and the exchange of goods and services with other countries.

In the literature on world food problems and standards of living there may be too much emphasis on the role of energy, food, and the improved utilization of natural resources and scientific developments in contrast to the emphasis on the population side of the problem. Society in general seems blandly to accept as fact its right to multiply itself in a completely unrestricted fashion without considering either the additional burden that this places upon natural resources and technology or the fact that, because of the lag between population increases and advances in technology, millions of the world's present and future citizens may be condemned to ignorance, poverty, disease, and famine. Living things are born, grow to maturity, reproduce, and die to the degree that these life functions are possible under existing conditions at a given time and place. An examination of natural phenomena will produce a multitude of examples demonstrating that any biological community may reach the point of saturation in terms of the carrying capacity of its surroundings. When this point is reached new individuals can come into being and prosper only at the rate that other individuals disappear from the community. Under such circumstances the community reaches a state of dynamic stability.

The human community is in no wise free of the basic laws of nature. Because of man's intelligence he is better able than any other biological form to modify his surroundings to his own taste and mitigate many of those forces that tend to destroy him. However, there is no evidence that this process can continue indefinitely and that the population of the globe can increase unchecked for an indefinite period in the future without catastrophic results. A simple illustration is the fact that the 2.6 billion human individuals occupying the world today, at the current rate of increase, will reach a total of 7 billion by the year 2050. When these figures are extrapolated into the future the obvious result is chaos induced by the sheer weight of numbers.

The radical increase in the population of the world is, of course, a simple function of geometric progression. It has been brought about by a variety of sociological and other factors, no one of which can be pointed to as the basic cause. These include various sorts of taboos, ignorance, and in the more sophisticated areas, a lack of understanding of ultimate consequences. Efforts by students of demography to delineate the problem and suggest remedial action are often met with opposition from groups that disagree with the conclusions reached or believe that their own philosophies more correctly apply. A hopeful sign is the fact that there are areas in the world where the problem has become so acute

that local leadership has been forced to recognize it and to begin to consider and experiment with ways for achieving the stabilization of populations before complete social breakdown occurs.

It is futile to belabor continuously the roles of science and technology in response to human need and to ignore completely the social implications involved. This becomes perfectly clear when one realizes that nearly two thirds of the world's citizens of today have substandard living conditions. While this situation is often viewed with alarm and with compassion, rarely is thought given to the fact that if we could suddenly bring the entire world up to the standard of living enjoyed by the most economically advanced nations we would immediately drain our natural resources at a rate approaching 100 times the current one. We should then have to expand this rate of consumption to care for further increases in population, with the certainty that we should rapidly exhaust most or all of the major natural resources upon which society now depends. It would be naive to assume that science would immediately find available substitutes in adequate quantities to fill the already rapidly widening gaps in critical quantities of petroleum, minerals, agricultural products, and all the other elements basic to what we consider an adequate level for normal existence.

The ingenuity of mankind will be put to the acid test during the coming generations. At best we are going to have to learn to cope with multitudes of new citizens, to feed, clothe, house, and educate them, and to teach them to live together under increasingly crowded conditions and decreasing standards of living. Those who now enjoy the highest standards may well find themselves in a situation in which many of the luxuries they took for granted in the 1940s and 1950s will be nostalgic memories. Also, unfortunately, this decrease in living standards in many advanced areas of the world will not necessarily be compensated for by commensurate improvements in the underdeveloped countries. On the contrary, it may probably simply represent a contribution to the increasing numbers of human beings in the world. The rich will get poorer and the poor will get still poorer as mankind continues to pour into society enormous numbers of individuals without provision for their adequate support. This suggests that an ever-increasing number of persons will be condemned to short lives of poverty and misery which, in turn, will adversely affect the lives and well-being of those individuals who by reason of their own industry and more fortunate geographical location have managed to develop relatively advanced standards of existence.

Although this paper is not to be considered a treatise on demography, my subject cannot properly be discussed if the population problem is entirely ignored. The success of every effort to improve food production and technology hinges in the last analysis upon whether society, through its myriad social, religious, political, and academic organizations, is

prepared to understand and to face this its greatest single problem. If so, the logical first step is to apply the intellect to the establishment of principles and practices by which society can begin to balance at the earliest possible moment the demands of mankind against nature's ability to respond. Failure to do so may mean a continuing and even an increasing series of wars, famines, epidemics, and other ills that plague mankind.

Conclusion

If I have been able to make one point by this discussion, I hope it is that the problems of providing the most basic needs for society affect us all and that, unless there is concerted and successful effort, the outlook for the future is not an attractive one. To a reasonable degree modern science and technology have provided, through agriculture and a wide variety of industries, enormous contributions to the well-being of mankind. Also, these have been fantastically successful by any comparison with previous years or decades. This is true even though the distribution of commodities has been inequitable and despite the fact that vast extremes exist between the so-called developed and underdeveloped areas of the world. There is, of course, no single solution and no one sector of society has more responsibility than any other for working toward the rational solution of this fundamental problem that affects all of mankind.

It is suggested that there are several ways in which we can forestall or at least delay some of the developments that presently seem imminent. We can see to it, for example, that science and technology are properly supported with funds and understanding so that, insofar as possible, new developments will keep pace with growing needs. We can attempt in logical and responsible ways to help less fortunate nations to develop their own natural and human resources so that they may more nearly approach standards of living that are essential and desirable. We can concentrate enormously greater emphasis on improvements in education so that vastly increased numbers of the world's citizens will have opportunities without which they can never hope to progress, and we can see to it that educational patterns do not become static, but remain flexible and dynamic and increasingly better. Subsequent improvements would accrue to all of the areas of science, to the social sciences, and to the humanities. Finally, it would seem that it is time now for society to make an objective examination of the world's population problem, to face the implications of increases that in many areas exceed 3 per cent per year. We must soon decide whether we are prepared to fall behind in each succeeding generation until there is no longer room to move and insufficient bread and opportunity for all, or whether we shall recognize and interpret the laws of nature in logical fashion and take appropriate measures not to violate them at the expense of our descendants.

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II. THE IMPACT OF AGRICULTURAL RESEARCH ON MEXICAN WHEAT PRODUCTION*

By Norman E. Borlaug

Mexican Agricultural Program, The Rockefeller Foundation, Mexico, D. F., Mexico

The cooperative Mexican Agricultural Program was initiated in 1943 at the invitation of the Mexican government with the objective of increasing the production of basic food. The program is a joint undertaking of the Mexican Ministry of Agriculture and The Rockefeller Foundation. The achievements in wheat production reported herein are based upon the research information and materials developed jointly by a large number of Mexican and Rockefeller Foundation scientists.

Wheat culture was introduced into Mexico in the early 1520's by the Spaniards shortly after the Conquest. Nevertheless corn, which was already extensively cultivated by the Indians when the Spaniards arrived, until very recently remained the only important bread grain. The *tortilla* which is the daily bread of the Mexican people is made principally from corn. Within the past twenty years, however, the consumption of wheat has increased to the point where it is now about one third that of corn.

Wheat today is consumed largely in the form of hard rolls known as *bolillos*. In recent years pan-type bread, spaghetti, macaroni, and pastry products have grown in popularity. The *tortilla* of the rural areas of the three northern states, Sonora, Chihuahua, and Coahuila, is generally made from wheat rather than corn.

The Problem

When the Mexican agricultural research program was organized in 1943, it was clear that wheat was one of the crops on which a concentrated research effort should be made. At that time more than 275,000 metric tons (10,175,000 bushels), or more than 55 per cent of the total consumption, were being imported (FIGURE 1). This importation cost approximately 100,000,000 pesos (21,000,000 dollars), which was by far the greatest expenditure for food imports. There were many indications that the demand for wheat would grow as more people began to consume bread and, moreover, that the increasing demand would certainly be accelerated by the rapid growth in population.

What was the situation with respect to wheat production when the research program was initiated? Wheat was grown primarily as a winter irrigated crop. It was planted from September through December and harvested from April through June, depending upon elevation. The varieties

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were all of spring habit and, with the exception of two Sonora varieties introduced from California, were of unknown origin. Varieties in the ordinary sense of the word did not exist, but were mixtures of many different types. All varieties were susceptible to stem rust caused by *Puccinia graminis tritici*, the most serious disease of this crop. In years when ecologic conditions were favorable to the pathogen, as was the case in Sonora in 1939, 1940, and 1941 and in the Bajío region in 1948, devastating epidemics brought economic ruin to the wheat producer. Cultural practices were very primitive in every area except Sonora, where mech-

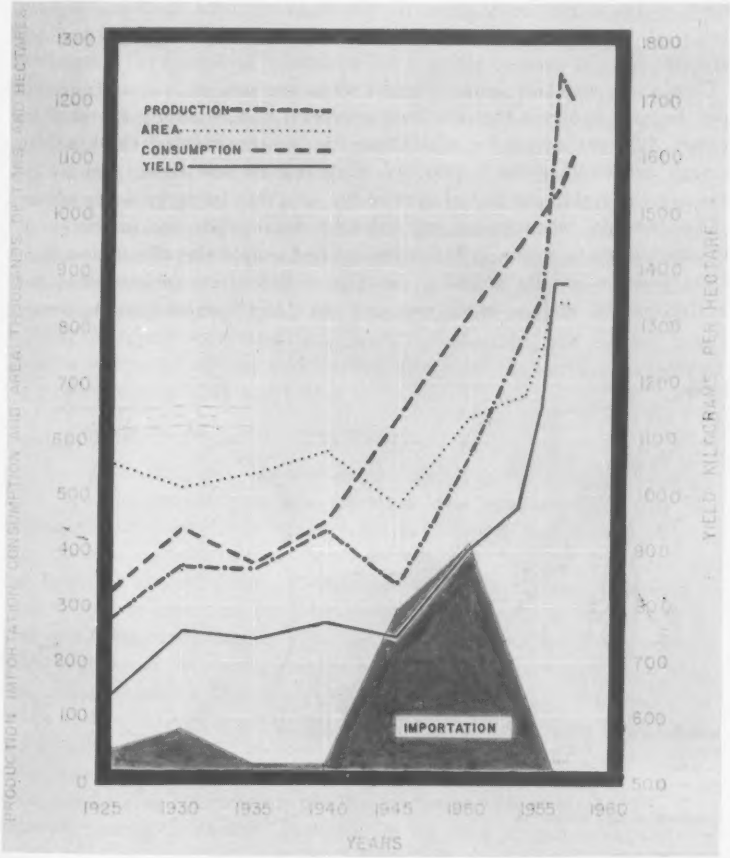

FIGURE 1. Wheat production, importation, consumption, yield, and area in Mexico between 1925 and 1957 (from Dirección General de Economía Rural C.E.I.M.S.A. and other sources of information).

anization and improved methods were well advanced. The Egyptian plow was the only implement used in land preparation and planting operations in most areas, and harvesting was done largely by use of a hand sickle.

During 1944 approximately 480,000 hectares (1,200,000 acres) were planted to wheat, with an average national yield of 750 kilos per hectare (11 bushels per acre). The only bright spot in the production picture was that represented by about 40,000 hectares in the Valle del Yaqui, Sonora, where yields averaged 1500 kilos per hectare (22 bushels per acre). However, this glimmer of hope was greatly overshadowed by the discouragingly low yields in all of the other areas, such as the Bajío, where wheat and corn had been grown for hundreds of years. In these regions yields often varied between 300 and 600 kilos per hectare (5 to 9 bushels per acre).

This, then, was the general picture when the program was initiated. It soon became apparent that the best approach was to attack the problem in two different ways: by increasing the area cultivated to this crop through establishing the feasibility of culture in new areas, and by increasing the yields per unit of area on the land then being grown to wheat.

The principal wheat-producing areas in the republic are indicated on the outline map in FIGURE 2. For the sake of simplifying the explanation of the problem and its solution, discussion henceforth is limited to the Pacific coastal region, which contains the "new" wheat-growing areas

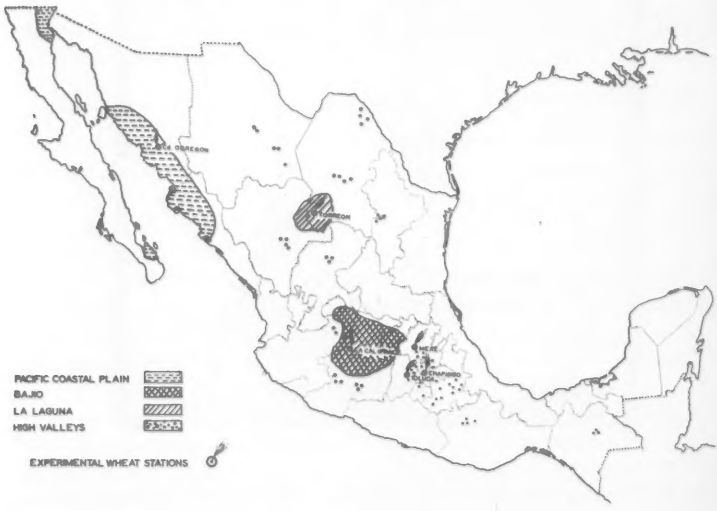

FIGURE 2. Wheat-production regions in Mexico, classified from a breeding standpoint.

of Sonora, Sinaloa, and Baja California; and the Bajío region, which includes the "old" wheat-producing areas of Querétaro, Guanajuato, Michoacán, and Jalisco.

The Approach

An analysis of the causes of low yields and lack of interest in wheat production indicated that through research it would be necessary to develop: (1) improved disease-resistant, high-yielding, good quality varieties that would also possess the agronomic characteristics making them well adapted to improved agricultural methods and practices; (2) basic information on the soil fertility levels of the different principal soil types where wheat was grown and, with this information, suitable fertilization and rotation practices as a stride toward attaining higher yields; (3) improved economical methods for land preparation, planting, and harvesting, which are all-important considerations in reducing costs and increasing yields; (4) the proper irrigation practices necessary for efficient utilization of the benefits expected from the use of improved varieties and fertilizer practices; and (5) basic pathological and entomological information on the important diseases and insect pests, and also to make this information available to the breeding program so that resistance could be incorporated into the new varieties, wherever feasible, or direct biological or chemical control measures devised.

Plant breeders, soil scientists, plant pathologists, and entomologists began a concentrated and coordinated attack on the various aspects of the problem during 1944 and 1945.

The Results

A broad breeding program was begun, which in the initial stages utilized for commercial purposes varieties developed by selection from materials introduced from other countries. Better varieties developed from crosses made in Mexico between the best "native" varieties and the best introduced stem-rust-resistant varieties became available to farmers for the first time in 1949. Despite two upsetting changes in the stem-rust race population in 1951 and 1953, this program produced varieties capable of increasing yields and providing protection from stem-rust losses (FIGURE 3).

The soil scientists began detailed studies of the nitrogen, phosphorus, and potash requirements of soils in each of the principal regions where wheat was grown. These and supplementary experiments revealed that in almost every area a deficiency of nitrogen limited wheat yields. The land recently cleared of desert vegetation in the new irrigation districts of Sonora and Sinaloa is the only area where lack of nitrogen is not a factor in limiting wheat yields (FIGURE 4). In the older areas, such as the Bajío, nitrogen must be applied in large quantities – up to 120 pounds per acre – in order to obtain yields of 45 to 60 bushels per acre. The

FIGURE 3. Field and greenhouse experimentation, both essential phases in the development of new varieties. (a) Wheat nursery in Toluca Valley, one of seven such nurseries where thousands of new lines are evaluated. (b) Greenhouse at Chapingo, where hundreds of the most promising lines are tested to determine their reaction to each of the prevalent races of the stem-rust pathogen.

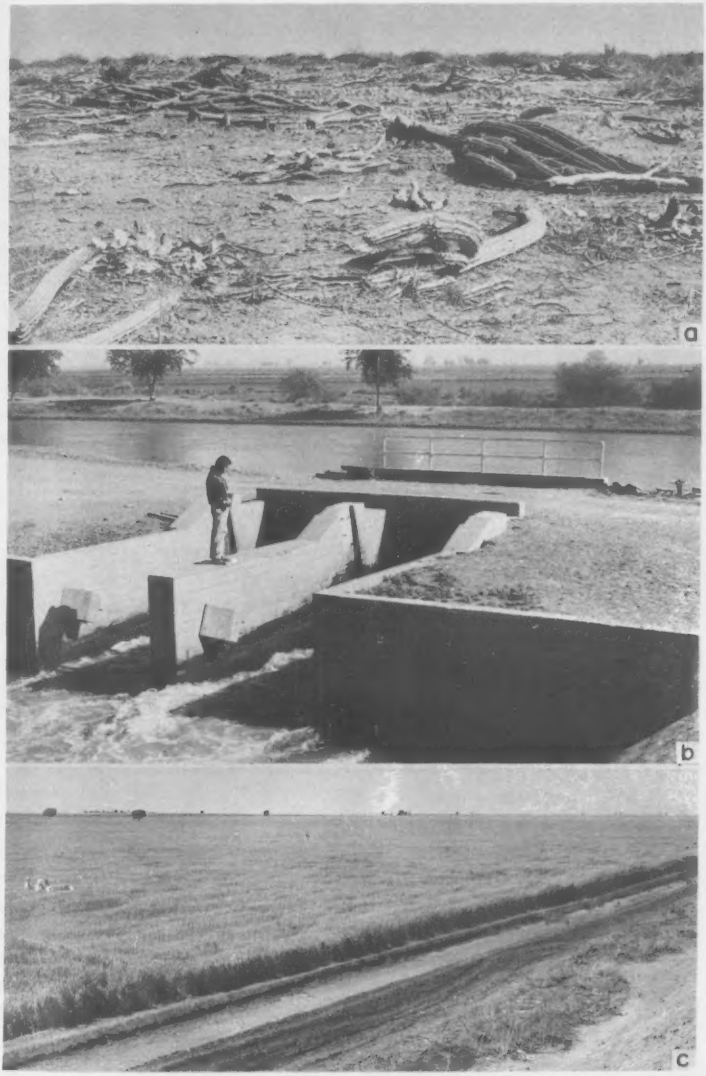

FIGURE 4. Expansion of wheat culture in Sonora and Sinaloa. (a) Desert vegetation being cleared to open new land for wheat production. (b) New government irrigation projects, providing water essential to the conversion of desert to productive wheat land. (c) Vast expanses of wheat replacing the desert vegetation in the past six years.

soils of the Bajío region are also deficient in phosphate, and this element as well as nitrogen must be applied in order to assure satisfactory yields. The soils of Sonora and Sinaloa do not respond to phosphates. All of the soils where wheat is grown have adequate quantities of available potash.

More recently the soil scientists have determined the most efficient method and time of application for the different fertilizers on each of the principal soil types. They have also studied the effect on yield of the interaction between the amount and the time of application of irrigation water at different levels of nitrogen fertilization. Their findings have been formulated into fertilizer and irrigation recommendations for each of the major soil types that are now followed by many wheat farmers.

The two most important developments in the improvement of wheat production in the Bajío region and similar areas have been the introduction of improved varieties and the use of chemical fertilizers. The introduction of these two factors into commercial wheat farming made it economically feasible for the first time to mechanize wheat production and thereby automatically initiate many other improvements in the culture.

Through the information developed by the agronomic research, it has become economically feasible to introduce successfully new land preparation, leveling, and planting techniques that reduce planting costs, achieve uniform distribution of irrigation water, and assure the adequate plant populations necessary to full utilization of varietal and fertilizer potentials.

The plant pathologists have provided information on stem-rust race populations and have evaluated many thousands of lines of promising wheats developed in the breeding program for their resistance to the various rust races. This information and assistance are invaluable in the development of disease-resistant varieties by the breeder.

Although until two years ago insects caused relatively little loss in the commercial crop, the entomologists have provided information and proposed controls for insect pests that might become destructive. One of the most potentially dangerous insects is the English grain aphid, *Macrosiphum granarium*, which became destructive in the Bajío region within the past three years. Prior to 1955 it had not been a problem in this area. The increased threat of this insect in recent years is correlated with the development of a more favorable microclimate within the grain field. This more favorable microclimate is created by the lush, rank vegetative growth of the wheat plants when heavy fertilization and adequate irrigation practices are followed.

How have the research findings affected wheat production? Their full impact has become felt only within the past three years. Although prior to that time advances had been made along certain fronts, it was not until 1954 that all the necessary information, materials, and methods

were both available and in sufficiently wide use among farmers to reveal their influence on production and yield. The results have exceeded even the most optimistic original expectations (FIGURE 1).

Effect on Cultivated Area

The area cultivated to wheat has increased from 500,000 hectares (1,250,000 acres) in 1946 to 840,000 hectares (2,100,000 acres) in 1957. A considerable part of this increase, approximately 250,000 hectares, has occurred in Sonora and Sinaloa where wheat has become the most important crop in several new large irrigation districts opened during the past five years. This area now accounts for 60 per cent of the national production of this cereal.

The early-maturing disease-resistant varieties that are efficient in the use of irrigation water and well adapted to combine harvesting have been the catalyst for the increase in the cultivated area of wheat in Sinaloa and Sonora. Since the land is largely "new," soil fertility levels are much higher than in other areas and the use of additional chemical fertilizers is of secondary importance. It should be emphasized that this expansion could not have been accomplished with the old native varieties without encountering devastating losses from rust epidemics.

Most of the remaining expansion has taken place in areas that have been cultivated for several hundreds of years and where yields were until recently extremely low. This increase is in many ways the most spectacular and gratifying change that has taken place. Yields have doubled, tripled, and, in some cases, even quadrupled in recent years through the application of the research findings. With these increased yields wheat has again become a profitable crop and the cultivated area has grown rapidly.

In areas such as the Bajío, where yields were formerly extremely low, the use of heavy rates of chemical fertilizers has been the primary catalyst. The use of improved varieties and improved cultural practices has been of secondary importance (FIGURE 5).

A third increase in the area grown to wheat was made possible by the introduction of wheat as a summer crop grown at elevations of 5500 feet and above during the rainy season that usually occurs between May and September. Formerly wheat could not be grown successfully during this season of the year because of losses caused by stem and stripe rusts and weeds. The use of rust-resistant varieties solved the former problem, and the use of 2,4-D-type weed killers removed the second obstacle. Although the area planted with summer wheat is still small, only 50,000 hectares, it can be expanded as more production is needed.

Effects on Yield

The over-all effect of the general application of research on wheat production from the grower's point of view is best shown by the changes

FIGURE 5. Rehabilitation of impoverished land. (a) Centuries of continuous cultivation with inadequate measures to maintain fertility produced wheat like this in many areas of the Bajío in 1945. (b) Response of impoverished land in the Bajío to fertilization, proper irrigation, and improved cultural practices. The plot on the left received an application of 150 kilos of nitrogen; the plot on the right received no nitrogen. (c) Soils in the Bajío rehabilitated under commercial conditions through the application of heavy fertilization and good cultural practices.

in yield per hectare. The average national yield in 1945 was 750 kilos per hectare (7½ bushels per acre), whereas by 1956 it had risen to 1370 kilos per hectare (21 bushels per acre). This has made wheat production profitable again despite a number of adverse economic factors. Within the past six years the wheat farmer has absorbed increases in machinery costs of 65 per cent, fuel costs of 60 per cent, fertilizer costs of 40 to 60 per cent, and labor costs of 40 per cent, while receiving only a 10 per cent increase in the price of grain. The farmer's ability to absorb these increased costs has been made possible by increases in yields per unit of cultivated area.

Effect on National Production

The combined effects of increases in cultivated area and yield per unit of area are summarized in FIGURE 1. The production increase can be summarized as follows:

Year	Production in metric tons
1945	400,000
1950	575,000
1955	875,000
1956	1,250,000
1957	1,200,000

This rapid increase in production within the past two years has made Mexico self-sufficient in wheat for the first time in its history. Moreover, it has created a surplus of 200,000 tons that will be of great assistance in offsetting the corn shortage and the reduction in wheat acreage during the forthcoming season caused by a very extensive and severe drought.

It is impossible to assign relative importance to the different research results that have contributed toward making Mexico self-sufficient in wheat production. It is sufficient to point out in a general way the contribution of each project.

The new varieties have been the principal "catalyst" in increasing production in some areas. In others they have been the "insurance policy" against crop losses. They have made possible more efficient use of both fertilizers and irrigation water. They are better adapted to mechanization and possess better quality characteristics for industrial purposes. The cumulative effect of all these advantages has been the cultivation of the improved varieties on approximately 90 to 95 per cent of the total area.

The soils research information has had tremendous impact, especially on the older agricultural areas. As late as 1950 virtually no chemical fertilizer was being used in Mexico. Only a few wheat farmers had begun to apply fertilizer by 1953, but by 1957 a very large percentage were using some fertilizer in those areas where the need was apparent. Some farmers applied up to 120 lb. of nitrogen per acre on their 1957 crop,

probably a heavier rate than was used anywhere else in the Americas. The investments in fertilizers on some wheat farms in the Bajío went as high as 600 pesos per hectare (19 dollars per acre) during 1957, but nevertheless proved to be sound investments. Some farmers are now harvesting 3 to 4 tons per hectare (45 to 60 bushels per acre) on the same land that yielded 400 to 700 kilos per hectare (6 to 10 bushels per acre) only four years ago.

Indirect or By-Product Effects of the Research Program

Certainly one of the most significant by-products of the program has been the awakening of the farmer to the values of agricultural research. Ten years ago Mexican farmers in general were not convinced of the value of research as a tool or aid in increasing their production and consequently improving their standard of living. A great gulf of misunderstanding and distrust separated the farmer from the agricultural scientist. The results obtained and the benefits derived by the farmer from the research program have in recent years brought about a completely new understanding soundly based upon mutual respect between farmer and agronomist. This new understanding has resulted in the elevation of the professional agronomist to the same rank of prestige formerly reserved for engineers, architects, lawyers, and members of other comparable professions.

A number of important businesses or industries have arisen and developed rapidly as research information has been applied commercially. These business enterprises could not grow and prosper until wheat yields had been increased. The introduction of new varieties and the use of chemical fertilizers were the keys that unlocked the door to the development of the farm machinery business in the Bajío region. Ten years ago, with very few exceptions, the only implements used in wheat cultivation were the Egyptian plow and the hand sickle. Today virtually all wheat planting in this area has been mechanized. Tractors, plows, disc harrows, land-leveling equipment, grain drills, and self-propelled combines are employed on most wheat farm operations. Thus the mechanization of this region has advanced from the Egyptian plow and hand sickle, which date back more than three thousand years, up to the most modern tractors and self-propelled combines of the twentieth century, all in a period of only ten years (FIGURE 6).

The chemical fertilizer business was nonexistent ten years ago. The first modern domestic ammonium sulfate production plant was opened in 1952. By the middle of 1953 demands for fertilizer had outgrown this plant's production capacity, and the consumption of fertilizers has continued to increase at a fantastic rate. Within a short span of five years, the manufacture of chemical fertilizers has grown into an industry with sales running into several hundreds of thousands of tons. Demand long ago outstripped domestic production and large quantities of fertilizers are currently being imported. Meanwhile the infant domestic chemical

FIGURE 6. Revolution in the mechanization of the wheat harvest in the Bajío region. (a) Common method of harvesting grain in 1945. (b) Grain being threshed in 1945 by treading animals. (c) Self-propelled combines now being used to harvest nearly all of the area.

fertilizer industry is frantically trying to expand its production facilities in an attempt to catch up.

Although this discussion has been confined to the impact of research on wheat production, many of the methods, techniques, and developments have a large "carry-over" value to other crops in the same area. The revolution in wheat production methods is thus of far wider implication and value than is evident only in production.

The increases in wheat yields in the Bajío region have also had other broad effects. Land rental values have increased sharply as wheat yields have risen. All rentals are now for cash, whereas ten years ago they were nearly always on a "share-of-the-crop" basis. Cash rentals have grown as investments in the crop have increased. In the Bajío region today it is common to find farmers investing from 1200 to 1500 pesos per hectare in a wheat crop. With such large investments, cash rentals are obviously more desirable than share rentals. Land prices have similarly risen sharply as wheat yields have increased.

Another intangible value that has evolved as a by-product of the research program is the establishment of close cooperation among scientists working on wheat in the different American republics. Some problems, such as the stem-rust epidemics, where the inoculum is airborne for hundreds of miles, are truly of an international nature. The outbreak of race 15B of stem rust in North America in 1950, which first became widespread in the United States, one year later had become equally disconcerting and dangerous to the wheat farmers of Mexico and Canada. As an outgrowth of the emergency created by this outbreak, there was developed a cooperative project coordinated by the United States Department of Agriculture, which is known as the Cooperative International Wheat Rust Nursery. Currently the uniform sets of seed collected for this nursery are being grown by cooperating scientists in more than twenty different countries. Data on diseases are taken and later compiled into a comprehensive report that is made available to agricultural scientists throughout the world. The Mexican research program has cooperated closely in the development of this project; through this and related projects, Mexico's young scientists have become personally acquainted with many of their counterparts in the other American republics.

The most significant and fundamental achievement of the entire research program is the development of an excellent corps of young Mexican scientists trained in the different sciences related to wheat production. This group, a number of whom have already received their doctorates, ranks high when compared with any other group of scientists working on wheat anywhere.

Not only have wheat research scientists been trained but, as the need has arisen, government-sponsored extension programs and seed distribution programs have been created. Many of the young men who are now

part of these organizations received their original training in research with the Mexican program.

Another valuable by-product of the Mexican program has been the training of young scientists from other Latin American countries. Scientists from nine different countries have spent from six months to more than a year in training with the Mexican program. When their training was completed they returned to their own countries to initiate or expand research work on wheat.

The Future

The research information and the methods and materials now available are adequate to supply wheat needs for the next ten years if they are extended to all areas where wheat is now grown. Since wheat is primarily an irrigated crop, it would appear advisable to carry over grain reserves of 10 to 20 per cent of annual consumption to provide for reduced production in those years when abnormally low precipitation in the watersheds of the principal reservoirs causes a shortage of irrigation water.

The production potential visualized with the information and materials now available takes into consideration the increased demand that will occur as a result of the increase in population and an even greater increase in per capita consumption of wheat. At the present time the population of Mexico is growing at a rate of 3.1 per cent per year. Wheat consumption now appears to be increasing at the rate of 9 per cent per year. The increase in per capita consumption undoubtedly reflects a rising living standard for many people.

Another factor that must be taken into consideration in formulating wheat production policy, if the production goals are to be met, is the need to provide compensation in price increases commensurate with increases in the cost of production. Although the grower has largely absorbed the increase in production costs during recent years, a point will soon be reached where this is no longer economically feasible, and where acreage now planted to wheat will be diverted to cotton.

The appearance of a new physiologic race of the stem-rust pathogen capable of attacking the commercial varieties could greatly jeopardize wheat production plans for the future. Several times during the past twenty-five years new races of stem rust have suddenly appeared in North America. When a new race arises, either through hybridization of preexisting races or through mutation, and becomes widely distributed, the whole structure of wheat production in North America is endangered. Whenever climatic conditions favorable to the pathogen coincide with the appearance and widespread distribution of a new rust race, serious regional epidemics develop and result in tremendous economic losses. Such was the case with race 15B in the United States and Canada from 1950 through 1954 when epidemics caused losses running into hundreds of millions of dollars.

Self-pollinated crops, such as wheat, oats, and barley, when bred by the conventional method, are extremely vulnerable to changes in races, since the entire population of a variety has identical characteristics for resistance. This danger is magnified even more by the fact that generally all the popular commercial varieties in any large geographic region carry the same type of rust resistance. Consequently, when a new race of the stem-rust pathogen develops that is capable of attacking that type of resistance, it finds a vast area of perfect culture medium upon which to increase. The result is a disastrous epidemic that literally explodes, in much the same way that a prairie fire explodes once a spark ignites in a vast expanse of dry grass.

The research program is now attempting to develop composite varieties that will be so constituted as to have several different types of resistance. It is highly improbable that a new stem-rust race would have the genetic make-up enabling it to attack all of the different genotypes present in the composite variety. Consequently the increase in inoculum will be slowed, and this in itself will delay the development of the epidemic to such a degree that the grain of even the susceptible components of the variety will mature. Such a variety has the added advantage that it can be modified quickly to meet shifts in the race population (FIGURES 7 and 8).

The composite variety is being developed by a modification of the backcross method. The best commercial variety in each region is being crossed independently to varieties containing all the known types of stem-rust resistance. Subsequently, each cross is backcrossed a number of times to the commercial variety. Eventually lines can be isolated that are phenotypically similar to the commercial parent or recurrent parent, but which are genotypically different for resistance to stem rust.

The composite variety that the farmer will grow will be a mechanical mixture of eight to ten lines that phenotypically are similar but genotypically are different for resistance to stem rust. Pure seed of each line incorporated into the composite is maintained in reserve. New lines can be developed as new sources of resistance are discovered. With this new approach the plant breeder can reform or reconstitute the composite variety rapidly whenever dictated by the shifts in the race population. If the development of composite varieties is to be successful, it must be based on accurate knowledge of the current rust race population, extensive greenhouse testing with various "tester" rust races to identify the best lines from each backcross, and maintenance of viable inoculum of all races of the pathogen collected in the area.

This new approach is designed to bring about a more permanent solution to a shifty and often frustrating biological problem. The research was initiated three years ago; within the next three years the feasibility of the new method should be either established or disproved.

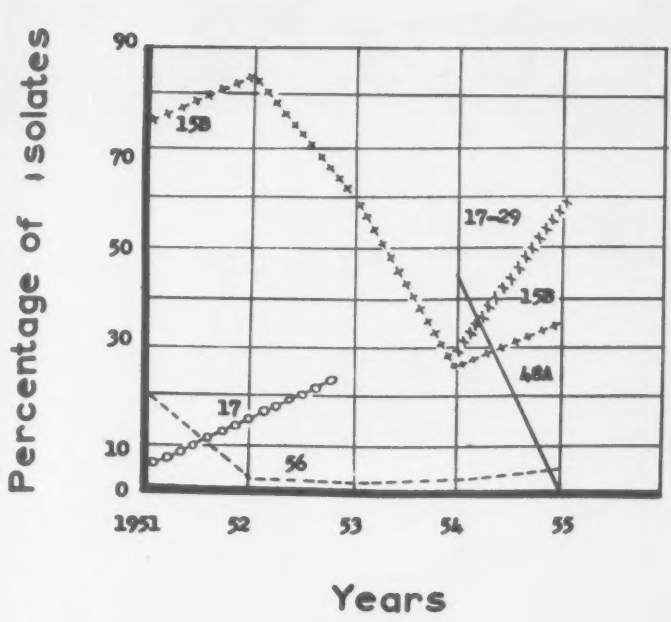

FIGURE 7. Shift in the race population of *Puccinia graminis tritici* in Sonora and Sinaloa from 1951 to 1956.

A second potentially valuable research project was begun two years ago in an attempt to develop a high-yielding, dwarf wheat variety with resistance to lodging (FIGURE 9). With dwarf wheat, it should be possible to apply higher rates of nitrogen fertilizer and increased numbers of irrigations without waste from lodging or from overproduction of stalk and leaf. If a good variety can be developed, it should then theoretically be possible to increase wheat yields by 30 to 40 per cent. Preliminary tests with lines that carry the Japanese Norin dwarf factor have been extremely promising. A breakthrough on this research front could add greatly to potential wheat production capacity.

Within the near future the transfer of over-all responsibility for future research on wheat will be made to Mexico's new corps of young, highly qualified scientists. The future success of this group will hinge primarily upon the ability and willingness of their government to provide them with adequate facilities and an environment conducive to scientific research. New problems will arise, as is always the case when dealing with biological phenomena, but this team of scientists, given proper conditions under which to work, will cope with them successfully.

FIGURE 8. Result of the appearance of a new rust race. Lerma 50 was resistant to stem rust until 1953, when it was killed by race 29.

As one of many scientists participating in this adventure in cooperative research, an adventure that was designed specifically to solve a food production problem and that has successfully achieved this objective, I have found the experience personally both extremely enjoyable and gratifying.

FIGURE 9. Development of dwarf varieties. The successful production of a commercial dwarf variety would prevent lodging and, with heavier fertilization, result in higher yields. The agronomist holds a plant of the popular commercial variety, Lerma Rojo, next to a promising dwarf line to indicate relative heights.

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NEW MEMBERS

Elected December 19, 1957

SUSTAINING MEMBERSHIP

Keller, George Ernest, Ph.D., Mathematics. Manager, Aeroelasticity, Vibrations and Analytical Developments, General Electric Company, Cincinnati, Ohio.

Stephano, Constantine Stephen, ScD., Organic Microchemistry of Cigarette Smoke. Vice-President, Research and Development, Stephano Brothers, Inc., Philadelphia, Pa.

Strother, Corneille Osburn, Ph.D., Research in Chemistry. Assistant Manager, Research Administration, Union Carbide Corporation, New York, N. Y.

ACTIVE MEMBERSHIP

Austin, Mary L., Ph.D., Zoology. Professor, Zoology Department, Wellesley College, Wellesley, Mass.

Balek, Richard William, Ph.D., Neurophysiology. Research Associate, Department of Physiology, University of Chicago, Chicago, Ill.

Bardos, V., M.D., Neurotropic Virus, Epidemiology and Rickettsia. Chief, Virus Section of the Microbiological Institute of Slovakia, Bratislava, Czechoslovakia.

Beard, Robert Gordon, Ph.D., Experimental Embryology. Carnegie Institution of Washington, Baltimore, Md.

Bertrand, Charles A., M.D., Cardiac. Director, Cardiopulmonary Department, The Roosevelt Hospital, New York, N. Y.

Borden, Walter A., B.A., Medicine. Senior Medical Student, New York University College of Medicine, New York, N. Y.

Bowers, John Edward, M.D., Biology and Medicine. Private Practice, Urology, Pompano Beach, Fla.

Carter, Robert, Cybernetics. Research and Study in Parapsychology, Chicago, Ill.

Chamey, Jesse, M.S., Biochemistry. Research Associate, Merck Sharp and Dohme Research Laboratories, Lansdale, Pa.

Coffey, George L., M.S., Antibiotics, Mycology. Associate Research Microbiologist, Parke, Davis & Company, St. Clair Shores, Mich.

Cole, George C., Ph.D., Virology. Research Associate, Department of Chemotherapy, Squibb Institute for Medical Research, New Brunswick, N. J.

Coveney, Richard J., B.S., Engineering and Management Consulting. Vice-President, Arthur D. Little, Inc., New York, N. Y.

Delvalle, Carlos M., M.D., Biology. (Cancer Research). Surgery and Surgical Practice, New York, N. Y.

Desmedt, Jean Edouard, M.D., Biology, Psychology. Assistant to Chief, Research Associé du Fonds National de la Recherche Scientifique, Brussels, Belgium.

Dettelbach, Harold R., Ph.D., Physiology and Pharmacology. Assistant to Director, Exploratory Development, Smith, Kline and French Laboratories, Philadelphia, Pa.

Diamond, J. L., M.D., Medicine. Medical Doctor, Oak Ridge, Tenn.

Dombek, Rudolph, M.D., Veterinarian Medicine and Research. Chief, Bioveta Veterinarian Institute, Teherezin, Czechoslovakia.

Dombush, Albert C., B.S., Microbiology. In Charge, Analytical Microbiology, American Cyanamid Company, Pearl River, N. Y.

Evenstein, Dorothy, B.A., Physiologic Hematology. Research Assistant to Doctor A. S. Gordon, New York University, Bronx, N. Y.

Feldman, Robert George, (M.D., June 1958), Disorders of the Nervous System, Psychopharmacol. Student, College of Medicine, University of Cincinnati, Cincinnati, Ohio.

Fisher, Jacob, M.A., Biology. Instructor, Science Education, New York University, New York, N. Y.

Fisher, W. P. MacClure, B.S., Virology. Tissue Culture. Research Associate, Merck Sharp & Dohme Research Laboratories, West Point, Pa.

Gianturco, Maurizio, Ph.D., Natural Products. Research Chemist, Newark, N. J.

Gosselin, Gilles, M.D., Haematology. Assistant Professor Medicine, University of Montreal, Montreal, Canada.

Hall, Hugh A., B.S., Biochemist. U. S. Vitamin Corporation, Brooklyn, N. Y.

Herman, Robert, M.A., Protozoology, Pa.asitology. Graduate Student, Flushing, N. Y.

Hess, Marilyn E., Ph.D., Pharmacology. Instructor, Pharmacology, Medical School, University of Pennsylvania, Philadelphia, Pa.

Hinsdill, Ronald D., B.S., Immunology. Laboratory Assistant, College of Medicine, University of Illinois, Chicago, Ill.

Hoekstra, Justin B., Ph.D., Physiology, Pharmacology, Experimental Medicine. Senior Research Scientist, Pharmacology, Bristol Laboratories, Inc., Syracuse, N. Y.

Jacolev, Leon, M.S., Chemical Engineering, Chemistry, Linguistics and Documentation. Technical Director, Associated Technical Services, Inc., Upper Montclair, N. J.

Jameson, Jean D., M.D., Psychiatry. Private Practice, Assistant Professor, Psychiatry, New York State Medical School, New York, N. Y.

Johansen, Erling, Ph.D., Dental Research. Assistant Professor, Dental Research and Chairman, Department of Dentistry and Dental Research, University of Rochester, Rochester, N. Y.

Jordahl, Clarence W., M.D., Internal Medicine, Pulmonary Disease, Chief, Tuberculosis, Public Health Service, Indian Hospital, Fort Defiance, Ariz.

Kammer, Lloyd Z., D.O., Anesthesiology. Head, Department of Anesthesia, Green Cross General Hospital, Akron, Ohio.

Keeshan, Sister Clarence Paul, (Ph.D. June, 1958), Nutrition of Protozoa. Assistant Professor, Biology, College of Saint Rose, Albany, N. Y.

Keller, Wayne H., Ph.D., Chemical Metallurgy. Head, Department of Chemistry, National Research Corporation, Cambridge, Mass.

Klier, Eugene Paul, Ph.D., Physical Metallurgy. Professor, Metallurgy, Syracuse University, Syracuse, N. Y.

Klosek, Richard Clinton, Ph.D. Candidate, Microbiology (Microphysiology). Research Assistant, Brooklyn, N. Y.

Kubelka, Vladimir, M.D., Microbiology. Assistant Professor, Microbiology-Epidemiology, Caroline University, Prague, Czechoslovakia.

Lieberman, Melvin, M.S., Virology and Tissue Culture. Virologist, Naval Medical Research, Great Lakes, Ill .

Ludwig, Lotte, Dr. Rer. Nat., Natural History. Medical Director, Cyanamid, G.m.b.H., München, Germany.

McAllister, Hugh Alexander, M.D., Obsteterics and Gynecology. Private Practice. Also Assistant Professor, School of Medicine, University of North Carolina, Chapel Hill, N. C.

McCoo, James W., Jr., B.S., Hematology and Radioisotope. Research Associate, Research Foundation Children's Hospital, Washington, D.C.

McLean, Richard A., M.A., Pharmacology, Cardiovascular Physiology. Senior Pharmacologist, Smith Kline and French Laboratories, Philadelphia, Pa.

Malek, Ivan, M.D., Biological Research. Chief, Biological Section, Czechoslovakian Academy of Sciences. Also Professor, Microbiology, Caroline University, Prague, Czechoslovakia.

Mariñelarena, Rafael, Ph.D., Microbiology. Associate Professor, Bacteriology, School of Medicine, University of Puerto Rico, San Juan, Puerto Rico.

Mason, Edward Allen, Ph.D., Physical Chemistry, Molecular Physics. Associate Professor, Institute for Molecular Physics, University of Maryland, College Park, Md.

Minick, Charles Richard, B.Sc., Medicine, Medical Student, Cornell University Medical College, New York, N. Y.

Moe, Robert A., Ph.D., Physiology. Head, Physiological Development, Pharmacology Division, Squibb Institute for Medical Research, Scotch Plains, N. J.

Murphy, Lt. Colonel Leslie C., D.V.M., Microbiology. Deputy Director, Division of Veterinary Medicine. Also Chief, Department of Veterinary Bacteriology, Walter Reed Army Medical Center, Washington, D. C.

Näf, Ulrich, Ph.D., Developmental Physiology of Plants. Assistant, The Rockefeller Institute for Medical Research, New York, N. Y.

Naiman, Barnet, Ph.D., Chemistry. Professor, Analytical Chemistry, The City College of New York, New York, N. Y.

O'Donnell, Walter E., M.D., Internal Medicine and Cancer Epidemiology. Assistant Professor, Preventive Medicine, Sloan-Kettering Division, Cornell University Medical College, New York, N. Y.

Patat, Franz, Ph.D., Polymerisation. Professor (Chemical Technologie), Technische Hochschule, Munich, Germany.

Patocka, F., M.D., Microbiology. Professor, Microbiology, Caroline University, Prague, Czechoslovakia.

Peck, F. Bruce, M.D., Virus Diseases and Clinical Immunology. Physician in charge, Virus Laboratory, Lilly Laboratories for Clinical Research, Indianapolis General Hospital, Indianapolis, Ind.

Pesek, Yarick, M.D., Virus Research. Research worker, Virus Institute, Bratislava, Czechoslovakia.

Pianotti, Roland Salvatore, M.S., Microbiology. Associate Scientist, Microbiology, Warner-Chilcott Laboratories, Morristown, N. J.

Prosky, Leon, M.S., Physiology. Teaching Assistant, Biochemistry, Rutgers University, New Brunswick, N. J.

Raska, Karel, M.D., Microbiology. Chief, Institute of Epidemiology and Microbiology, Ministry of Health, Prague, Czechoslovakia.

Richardson, Burt, M.S., Guided Missiles. Supervisory Electronic Engineer, Electronic Standards and Laboratory Branch Head, U.S. Naval Air Missile Test Center, Ventura, Calif.

Riegel, Byron, Ph.D., Chemical Research and Development. Director, Chemical Research and Development, G. D. Searle & Company, Chicago, Ill.

Ross, William D., B.S., Inorganic Chemistry. Chemist, E. I. du Pont de Nemours & Co., Wilmington, Del.

Rush, Richard W., Ph.D., Geology. Senior Scientist II, Creole Petroleum Corporation, Caracas, Venezuela.

Salamon, Ivan Istvan, Ph.D., Chemistry of Natural Products. Assistant, Department of Steroid Biochemistry and Metabolism, Sloan-Kettering Institute, New York, N. Y.

Salwen, Martin J., M.D., Medicine. Rotating Interne, Hospital of St. Raphael, New Haven, Conn.

Saum, Arthur M., Ph.D., Polymer Chemistry, Synthetic textile fibers. Research Associate, "Orlon" Research Division, Textile Fibers Department, E. I. du Pont de Nemours & Co., Waynesboro, Va.

Scardino, Vito, M.D., Pathology. Assistant Resident, Pathology, Mount Vernon, N. Y.

Schaad, Raymond E., Ph.D., Petroleum Research. Research Chemist and Patent Agent, Universal Oil Products Company, Des Plaines, Ill.

Schallert, William L., B.S., Meteorology. Assistant Professor, Meteorology. Also Head, Division of Meteorology, Department of Physics and Meteorology, Oklahoma State University, Stillwater, Okla.

Schmitt, Harrison Ashley, Ph.D., Mining Geology. Consulting Mining Geologist and Manager, Geology and Exploration (Houston, Texas) Duval Sulphur and Potash Company, Silver City, N. Mex.

Schultze, Norman Clemens, B.S., Chemistry. Manager, Technical Service, Olin Mathieson Chemical Corporation, Industrial Division, Silver Spring, Md.

Schwarz, T. Werner, Ph.D., Pharmaceutical Chemistry. Assistant Professor, School of Pharmacy, University of California Medical Center, San Francisco, Calif.

Secco, E. Anthony, D.Sc., Kinetic and Structural Studies. Associate Professor, Chemistry, St. Francis Xavier University, Nova Scotia, Canada.

Senum, Tellef, Ph.D., Nutrition. General Manager. Also in charge of Research, Wm. T. Thompson Company, Los Angeles, Calif.

Seymour, G. Wilbur, S.B., Chemistry. Vice-President, Technical and Process Control, Celanese Corporation of America, Charlotte, N. C.

Shaffer, Robert E., B.S., Metallurgy. Associate Professor, Engineering, University of Buffalo, Buffalo, N. Y.

Shapley, Alan H., A.B., Radio Physics. Chief, Sun-Earth Relationship Section, National Bureau of Standards, Boulder, Colo.

Shatin, Harry, M.D., Medicine. Chief, Dermatology, Veterans Administration Hospital, Bronx, N. Y.

Shen, Tsung-Ying, Ph.D., Organic and Pharmaceutical Chemistry. Senior Chemist, Merck Sharp & Dohme Research Laboratories, Metuchen, N. J.

Shepard, E. R., Ph.D., Pharmaceuticals. Head, Department, Applications Research, Eli Lilly and Company, Indianapolis, Ind.

Sherburne, Russell Knight, Ph.D., Physics. Chief Physicist, Physical Science Laboratory, New Mexico College of Agriculture and Mechanic Arts, State College, N. Mex.

Sherwood, Reginald C., Ph.D., Food Technology. Vice-President and Technical Director, Sherwin Chemicals, Inc., New York, N. Y.

Short, Byron E., Ph.D., Heat Transfer and Thermodynamics. Professor, Mechanical Engineering, University of Texas, Austin, Texas.

Shumway, George A., M.S. (Ph.D. Candidate). Geophysics and Geology. Oceanographer, U.S. Navy Electronics Laboratory, La Jolla, Calif.

Signer, Ralph J., M.S., High Polymers. Research Chemist, Plastic Film Development, Villa Park, Ill.

Silverman, Milton, Ph.D., Biochemistry and Metabolism. Biochemist, Arctic Health Research Center, Anchorage, Alaska.

Simon, Simon A., B.S. Cellulose Cotton and Textile Finishing. Internal Chemical Consultant, Research Division, Chicopee Manufacturing Corporation, Chicopee Falls, Mass.

Simons, Harold Lee, Ph.D., Physical Chemistry. Research Chemist, Kendall Mills, Walpole, Mass.

Sirianni, Aurelio Frederick, Ph.D., Physical Chemistry. Associate Research Officer, National Research Laboratories, Ottawa, Canada.

Skinner, Kenneth G., M.S., Ceramic Engineering, Solid State Physics. Ceramic Engineer, Naval Research Laboratories, Washington, D.C.

Skinner, Selby M., Ph.D., Electrical and Mechanical Properties of Polymers. Associate Professor, Physical Chemistry, Case Institute of Technology, Cleveland, Ohio.

Slawsky, Zaka Israel, Ph.D., Molecular Physics and Gas Dynamics. Chief, Ballistics Department, U.S. Naval Ordnance Laboratory, Silver Spring, Md.

Sleator, William W., Jr., Ph.D., Muscle (Activation and Contraction Processes). Associate Professor, Biophysics, Physiology, Washington University School of Medicine, St. Louis, Mo.

Slonim, Dimitri, M.D., Virus Research. Director, Polio Institute, Prague, Czechoslovakia.

Sloth, Eric N., M.S., Nuclear Chemistry. Associate Chemist, Argonne National Laboratory, Naperville, Ill.

Slud, Maurice H., M.A., Mathematics, Biology and Psychology. Research Mathematician, Cornell Aeronautical Laboratory, Depew, N. Y.

Small, LaVerne D., Ph.D., Pharmaceutical Chemistry. Professor, Pharmacy and Phamaceutical Chemistry, College of Pharmacy, University of Nebraska, Lincoln, Nebr.

Small, Walter M., A.B., Petroleum Geology. Geological Consultant, Standard Oil Company of New Jersey, Cooperstown, Pa.

Smart, Charles L., Ph.D., Fibers. Senior Research Chemist, Celanese Corporation of America, Millington, N. J.

Smith, Allen S., Ph.D., Chemical Engineering. Professor, University of Notre Dame. Also Consultant to Wheelabrator Corporation, South Bend, Ind.

Smith, Chester W., LL.B., Mechanical Engineering. Adjunct Professor, Aeronautical Engineering, New York University, New York, N. Y.

Smith, E. C., Ph.D., Analytical Methods. Professor, Chemistry. Trinity University, San Antonio, Texas.

Smith, E. Westley, Ph.D., Chemistry. Assistant Chief, Research Solvay Process Division, Allied Chemical and Dye Corporation, Syracuse, N. Y.

Smith, Kenneth Alden, D.Sc., Nuclear Physics. Research Director and Consulting Physicist, Alden Corporation, Burbank, Calif.

Smith, Ora, Ph.D., Horticulture. Professor, Vegetable Crops, Cornell University, Ithaca, N. Y.

Smith, Ralph G., Ph.D., New Drugs. Chief, New Drug Branch, U. S. Food and Drug Administration, Washington, D. C.

Smith, William Ogden, B.S., Physics. Physicist, U. S. Geological Survey, Washington, D. C.

Smyth, Robert D., Bacteriology. Bacteriologist, William H. Rorer, Inc., Philadelphia, Pa.

Snepvangers, Rene Charles, M.E., Audio and Recording. Project Engineer, C.B.S. Laboratories, Croton-on-Hudson, N. Y.

Snipper, Lawrence P., Ph.D., Biochemistry. Instructor, Chemistry, Los Angeles Valley Junior College, North Hollywood, Calif.

Snowden, Stanley C., Ph.D., Nuclear Physics. Staff Member, Bartol Research Foundation, Swarthmore, Pa.

Snyder, Andrew J., M.S., Dry Color Pigments. Assistant Professor, Chemistry, University of Alabama, Tuscaloosa, Ala.

Snyder, Edward B., Ph.D., Physical Chemistry. Vice-President and Chief Engineer, Bently Harris Manufacturing Company, Conshohocken, Pa.

Snyder, J. Robert, Ph.D., Process and Product Development. Research Chemical Engineer, Armstrong Cork Company Research and Development Center, Lancaster, Pa.

Snyder, Robert Harvey, Ph.D., Chemistry. Manager, Materials Research, Product Development Division, United States Rubber Company, Grosse Pointe Park, Mich.

Socolow, Arthur A., Ph.D., Economic Geology. Geologist, Pennsylvania Geological Survey, Harrisburgh, Pa.

Soday, Frank John, Ph.D., Anthropology. Vice-President, Research and Development, The Chemstrand Corporation, Decatur, Ala.

Soldano, Benny A., Ph.D., Physics and Chemistry. Chemist, Oak Ridge National Laboratories, Oak Ridge, Tenn.

Solomon, Joel Martin, Sc.M., Immunology. Lt. J.G., U.S. Public Health Service, Bethesda, Md.

Solow, Max, Ph.D., Solid State Physics. Research Physicist, Solid State Physics, Naval Ordnance Laboratory, Silver Spring, Md.

Soloway, Saul, Ph.D., Organic Chemistry. Consulting Chemist, Faculty, The City College of New York, New York, N. Y.

Sondheimer, Ernest, Ph.D., Biochemistry. Research Associate, State University College of Forestry, Syracuse, N. Y.

Sorenson, James, Metallurgy. Chief Metallurgist, Four Wheel Drive Auto Company, Clintonville, Wis.

Souders, Mott, Jr., Sc.D., Chemical Engineering. Director, Oil Development, Shell Development Company, Emeryville, Calif.

Southam, F. William, Ph.D., Kinetics, Metallurgy. Group leader, Aluminium Laboratories Ltd., Arvida, Quebec, Canada.

Southwick, Philip L., Ph.D., Organic Chemistry. Professor, Chemistry, Carnegie Institute of Technology, Pittsburgh, Pa.

Sparano, Benjamin M., Ph.D., Biology. Research Scientist, American Cyanamid Company, Pearl River, N. Y.

Spence, Robert D., Ph.D., Physics. Professor, Physics, Michigan State University, East Lansing, Mich.

Spiegl, Charles J., Ph.D., Toxicology. Director, Toxicology Laboratories, Central Research and Engineering, Continental Can Company, La Grange Park, Ill.

Spies, Joseph R., Ph.D., Chemistry of Allergens. In charge, Chemistry Unit, Allergen Section, U.S. Department of Agriculture, Washington, D.C.

Spindt, Roderick S., Ph.D., Organic Chemistry. Staff Assistant, Automotive Engineering Division, Gulf Research and Development Company, Pittsburgh, Pa.

Spretnak, Joseph William, Ph.D., Metallurgy. Professor, Metallurgy and Research Supervisor, The Ohio State University, Columbus, Ohio.

Sprott, D. A., Ph.D., Mathematical Statistics. Biogeneticist, Department of Psychiatry, University of Toronto, Toronto, Canada.

Stansbrey, John J., Ph.D., Physical Chemistry. Research Specialist, Experimental Designs and Statistical Analysis in Physics and Chemistry, Dayton, Ohio.

Stanton, Gilbert, M.S., Dentistry, Nutrition. Dentist, Doctoral candidate, Nutrition Department, Columbia University, New York, N. Y.

Stauffer, Charles Henry, Ph.D., Physical Chemistry. Associate Professor, Chemistry, Worcester Polytechnic Institute, Worcester, Mass.

Steffey, W.W., Ph.D., Physics and Chemistry. Professor, Physics, Austin College, Sherman, Texas.

Stein, Gustav A., Ph.D., Medicinals. Research Associate, Merck & Company, Inc., Rahway, N. J.

Steiner, Robert F., Ph.D., Physical Biochemistry. Chemist, Naval Medical Research Institute, Bethesda, Md.

Stendahl, Gunnar D., Physics. Research Metallurgist, Central Research Laboratories, American Smelting and Refining Company, Avenel, N. J.

Stenger, Vernon A., Ph.D., Analytical Chemistry. Director, Special Services Laboratory, The Dow Chemical Company, Midland, Mich.

Stern, Joel R., Ph.D., Biological Chemistry. Research Biochemist, Children's Memorial Hospital, Chicago, Ill.

Stevens, Frank Joseph, Ph.D., Organic Chemistry. Associate Professor, Chemistry, Alabama Polytechnic Institute, Auburn, Ala.

Stevenson, David P., Ph.D., Chemical Physics. Director, Fundamental Research, Shell Development Company, Emeryville, Calif.

Stewart, Laura C., Ph.D., Biochemistry. Chemist, Institute Arthritis and Metabolic Disease, National Institutes of Health, Bethesda, Md.

Stimson, Sister Miriam Michael, Ph.D., Chemistry. Chairman, Division of Natural Science. Also Professor, Chemistry, Siena Heights College, Adrian, Mich.

Stokes, Ruth, W., Ph.D., Mathematics. Associate Professor, Mathematics, Syracuse University, Syracuse, N. Y.

Stone, M.D., Ph.D., Mathematics and Engineering. Manager, Research and Development, United Engineering and Foundry Company, Pittsburgh, Pa.

Stone, Richard S., Ph.D., Nuclear Physics. Staff Physicist, General Atomic Company, San Diego, Calif.

Stonehill, Albert A., Ph.D., Pharmaceutical Chemistry. Chief, Department of Pharmaceutical Chemistry, Ethicon, Inc., Somerville, N. J.

Stowell, Ellery C., Jr., Ph.D., Biochemistry. Supervisory Biochemist, Dentistry Research, Medical Research Programs, Veterans Administration Hospital, Los Angeles, Calif.

Strandberg, Malcom, W.P., Ph.D., Microwave Physics. Associate Professor, Physics, Massachusetts Institute of Technology, Cambridge, Mass.

Strandhagen, Adolf G., Ph.D., Theoretical and Applied Hydrodynamics. Professor and Head of Department of Engineering Mechanics, University of Notre Dame, Notre Dame, Ind.

Street, John N., Ph.D., Chemistry. Director, Chemical Laboratories, The Firestone Tire and Rubber Company, Akron, Ohio.

Strelzoff, Samuel, M.Sc., Chemical Engineering. General Sales Engineer, New York, N. Y.

Streng, Alex C., Ph.D., Physics and Chemistry. Research Associate, Research Institute, Temple University, Philadelphia, Pa.

Strube, Richard E., Ph.D., Medicinal Chemistry. Research Chemist, The Upjohn Company, Kalamazoo, Mich.

Struik, Saly Ruth, D.M., Mathematics. Belmont, Mass.

Strum, Peter D., M.S., Electronics Engineering. Director, Research, Ewen Knight Corporation, Needham, Mass.

Stuart, Ronald S., Ph.D., Organic Chemistry. Manager, Scientific Division, Merck and Co., Ltd., Town of Mount Royal, Quebec, Canada.

Sturgis, Bernard Miller, Ph.D., Combustion, Organic Chemicals. Director, Du Pont Petroleum Laboratory, Wilmington, Del.

Szwarc, Michael M., Ph.D., Chemical Kinetics. Research Professor, State University College of Forestry, Syracuse University, Syracuse, N. Y.

Seymour, Werthamer, M.D., Medicine. Pathologist and Director, Laboratories, Paul Kimball and Point Pleasant Hospitals, Lakewood, N. J.

Willett, Norman P., Ph.D., Microbiology. Research Associa e, Squibb Institute for Medical Research, New Brunswick, N. J.

Witlin, Bernard, Sc.D., Microbiology and Public Health. Associate Professor, Philadelphia College of Pharmacy and Science, Philadelphia, Pa.

Zinner, Doran D., D.D.S., Microbiology. Director, Dental Research National Children's Hospital of Miami, Research Assistant Professor, Department of Microbiology, University of Miami, Coral Gables, Fla.

STUDENT MEMBERSHIP

Chiarodo, Andrew J., A.B., Embryology. Graduate Student and Assistant, Biology Department, Fordham University, Bronx, N. Y.

Cohen, Donald, B.A., Medicine. Medical Student, New York University College of Medicine, New York, N. Y.

Finkelstein, Solon Ira, B.A., General Medicine. Medical Student, New York, N. Y.

Gottlieb, Abraham A., A.B., Medical Student, Bronx, N. Y.

Kauff, Richard Eden, B.A., Medicine. Medical Student, New York University-Bellevue Medical Center, New York, N. Y.

Kline, Robert Monte, B.S., Student, New York University-Bellevue Medical College, New York, N. Y.

Lauritzen, Herbert, M.A., Tissue Culture and Differentiation. New York University College of Medicine, New York, N. Y.

Loeb, Lawrence A., B.S., Medicine. Medical Student, Bronx, N. Y.

Loeser, John David, B.A., Medicine-Neurophysiology. Student, New York University-Bellevue, College of Medicine, New York, N. Y.

Manheimer, Robert, M.A., Biology. Student, Brooklyn, N. Y.

Moss, James E., A.B., Student, New York University-Bellevue College of Medicine, New York, N. Y.

Podvoll, Edward M., B.A., Biochemistry. Student, New York University-Bellevue College of Medicine, New York, N. Y.

Rosensweig, Norton S., B.A., New York University College of Medicine, New York, N. Y.

Smart, K. Marilyn, M.A., Immunochemistry. Graduate Student, Cornell University Medical College, New York, N. Y.

Vigliano, Edward M., B.S., Medicine. Medical Student, New York, N. Y.